(12) UK Patent Application (19) GB (11) 2 324 676 (13) A

(21) Application No 9708186.3

(22) Date of Filing 23.04.1997

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(51) INT CL6
H04Q 11/04 , H04L 12/56

(52) UK CL (Edition P)
H4K KTK

(56) Documents Cited
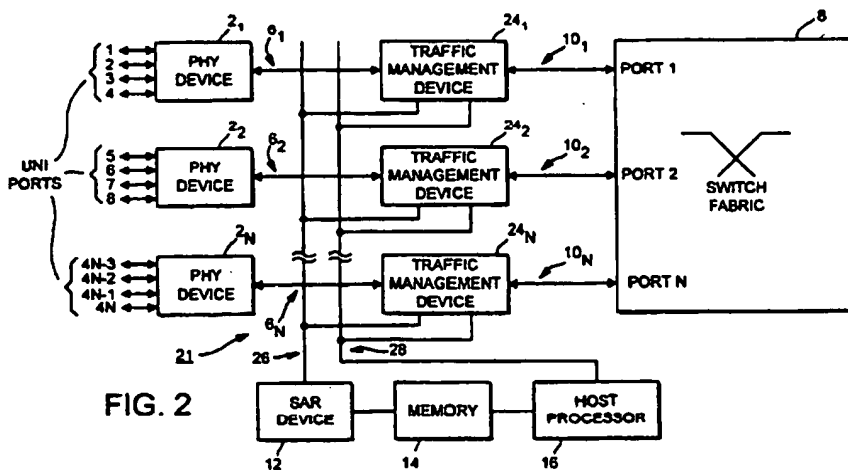EP 0703718 A2   EP 0531599 A1   US 5570362 A

(58) Field of Search
UK CL (Edition O) H4K KTK , H4P PPS
INT CL6 H04L 12/56 , H04Q 11/04
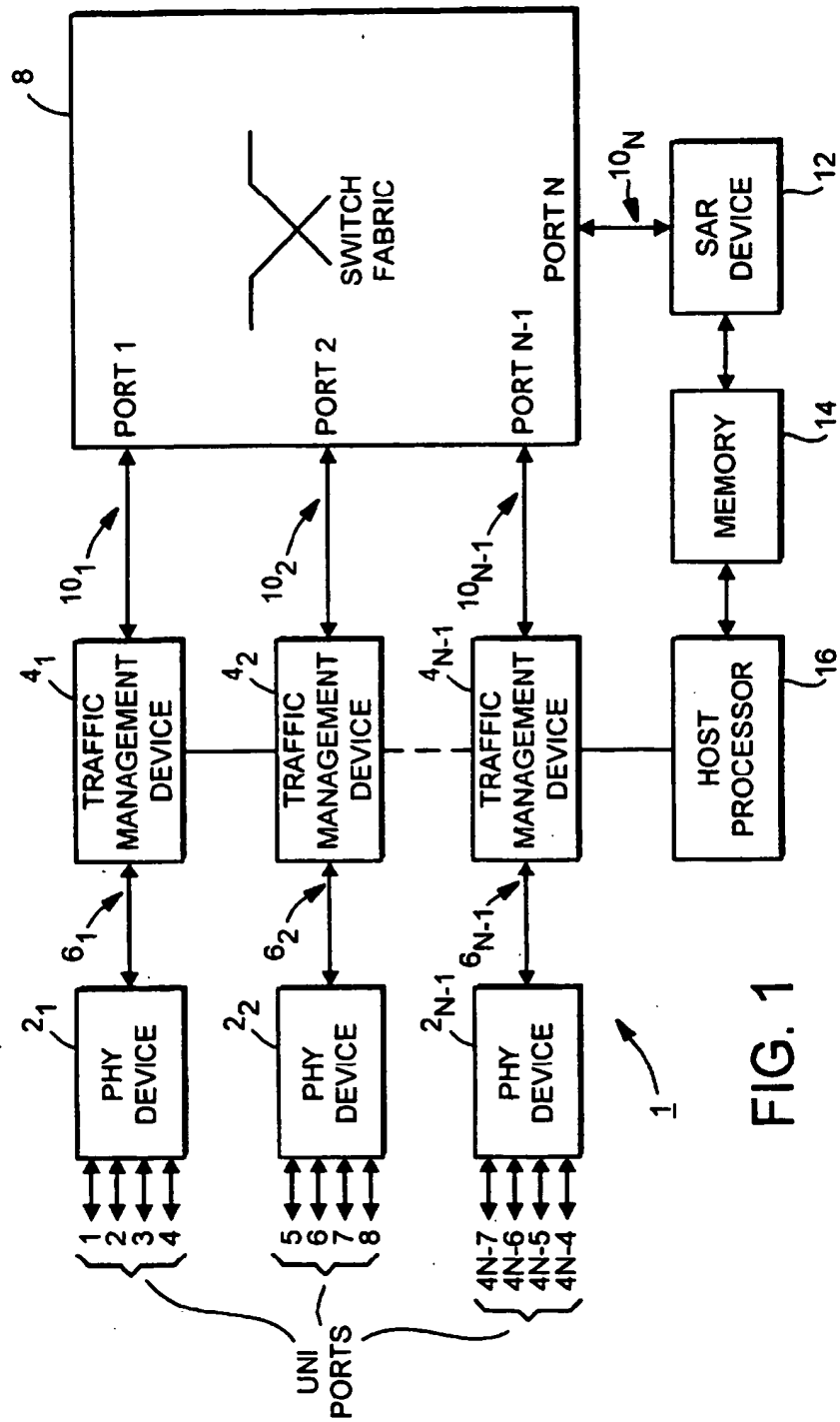Online: WPI, INSPEC

(54) Abstract Title
Interfacing to SAR devices in ATM switching apparatus

(57) A switching apparatus, for use in an ATM network, includes a switch fabric 8 for switching ATM cells, a segmentation-and-reassembly (SAR) device 12 for reassembling packets from ATM cells, and a plurality of traffic management (TM) devices 241-24N. Each TM device 24 receives ATM cells delivered to associated ports of the apparatus and is connected by a first data delivery path 10 to the switch fabric and by a second data delivery path 26 directly to the SAR device 12. The TM device identifies those received ATM cells that belong to one or more predetermined types of packets requiring reassembly by the SAR device, and delivers these to the SAR device 12 via the second data delivery path 26 for reassembly into packets. Cells not requiring reassembly are delivered to the switch fabric 8 via the first data delivery path 10 for switching by the switch fabric. This means that reassembly cells do not pass through the switching fabric in the course of transfer from the TM device to SAR device. This increases the switching fabric's capacity to switch other data. In Figure 11 (not shown) the SAR device is part of, or is replaced by, an internet-protocol (IP) switch controller used to detect IP flows through the switching apparatus.

FIG. 2

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FIG. 1

FIG. 2

FIG. 3

FIG. 4

SAP

SSCS	SERVICE SPECIFIC CONVERGENCE SUB-LAYER (MAY BE NULL)
CPCS	COMMON PART CONVERGENCE SUB-LAYER
SAR	SEGMENTATION AND REASSEMBLY

SAP

FIG. 5

CPCS-SDU

| CPCS-PDU PAYLOAD | | PAD | CPCS-PDU TRAILER |

← CPCS-PDU →

AUU 0 | SAR-PDU PAYLOAD

← SAR-SDU →

AUU 0 | SAR-PDU PAYLOAD

← SAR-SDU →

AUU 1 | SAR-PDU | PAYLOAD

← SAR-SDU →

| CELL HEADER | CELL INFORMATION FIELD |

← ATM-PDU = CELL →

FIG. 6

CPCS-PDU PAYLOAD

CPCS-SDU	PAD	CPCS-PDU TRAILER

CPCS-PDU

CPCS -UU	CPI	LENGTH	CRC

CPI:	COMMON PART INDICATOR	1 OCTET
CPCS-UU:	CPCS USER TO USER INDICATION	1 OCTET
PAD:	PADDING	0.47 OCTETS
CRC:	CYCLIC REDUNDANCY CHECK	4 OCTETS
LENGTH:	LENGTH OF CPCS-SDU	2 OCTETS

FIG. 7

CELL HEADER ◄—————► ◄————— 48 OCTETS —————►

			SAR-PDU PAYLOAD
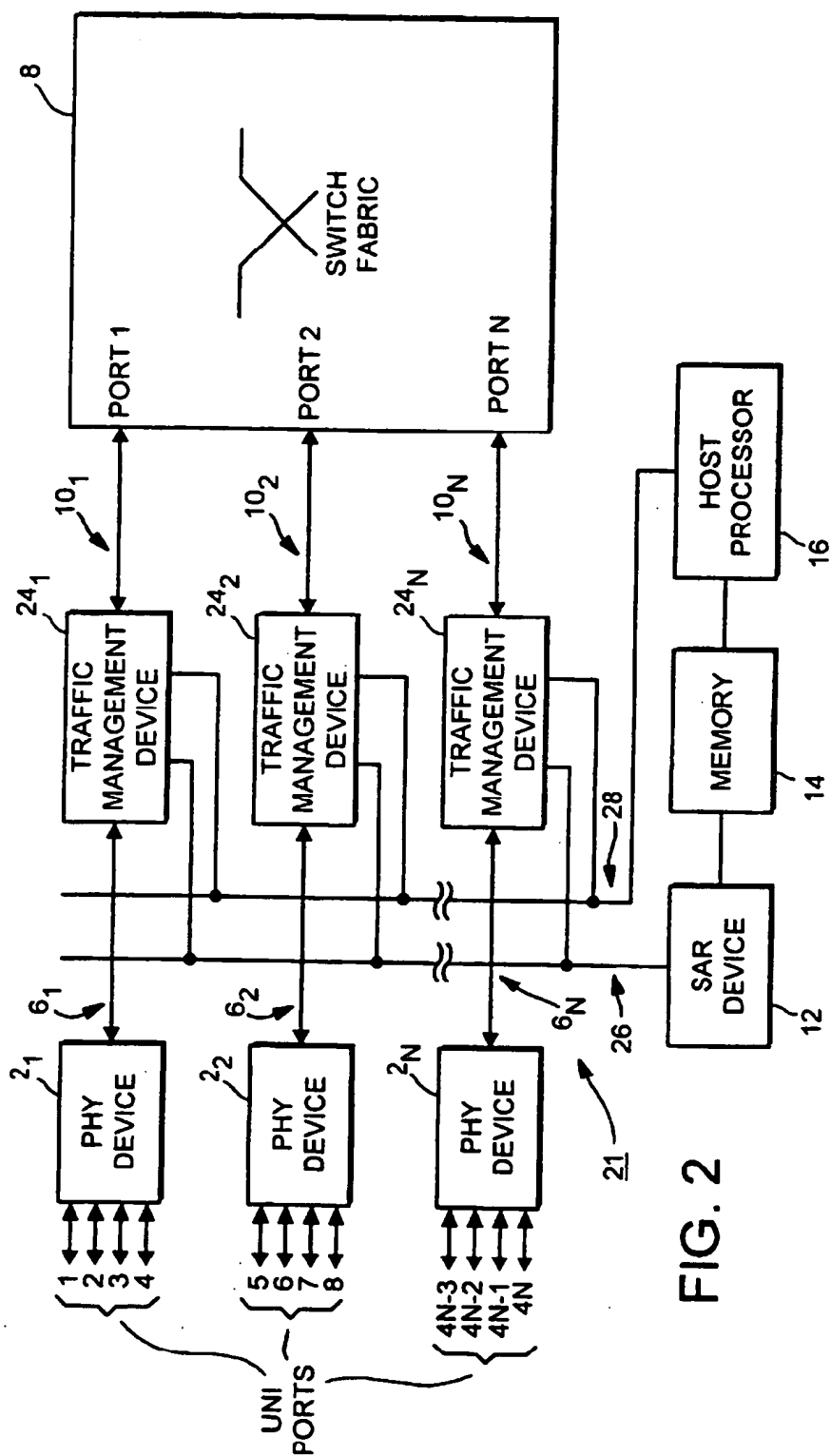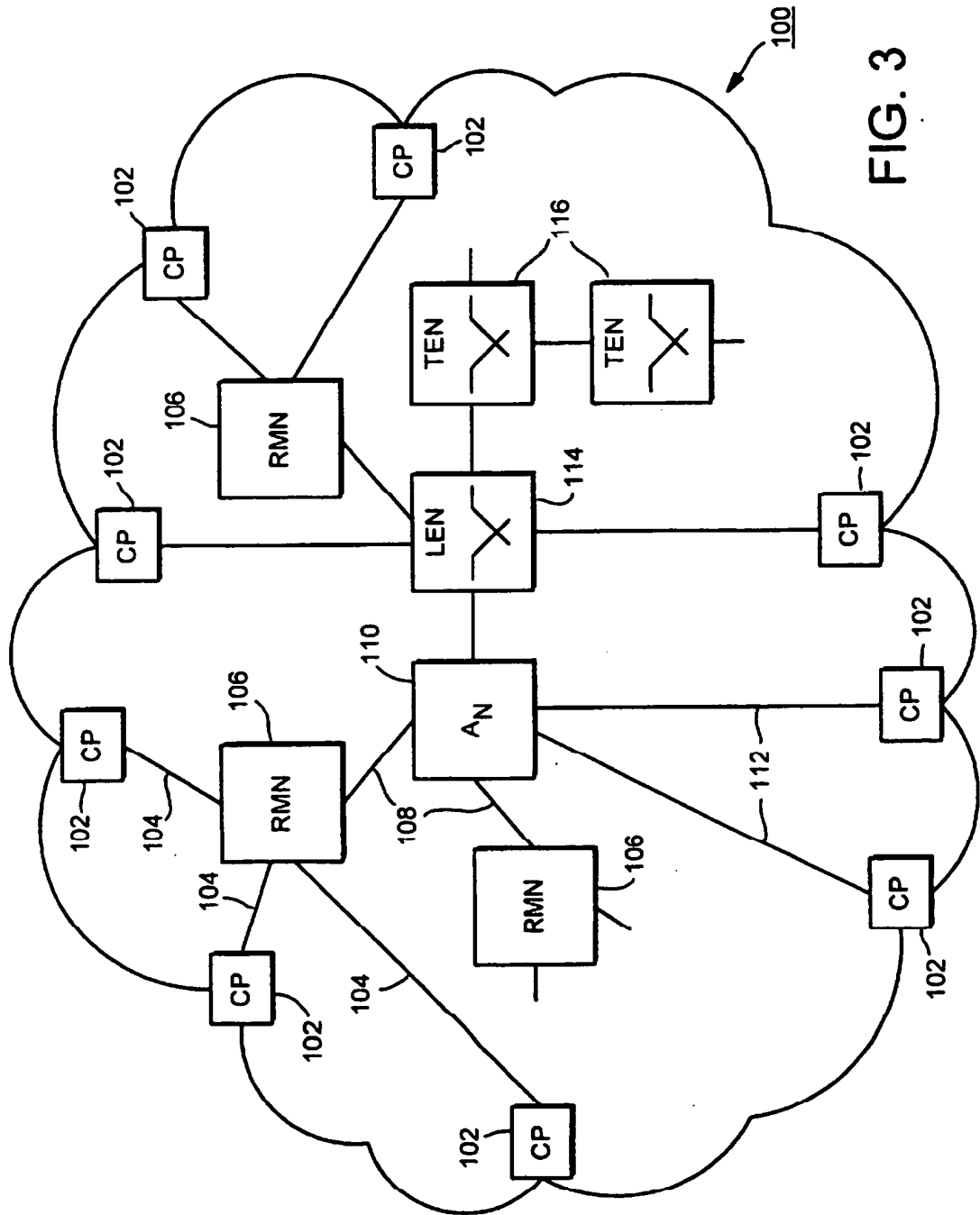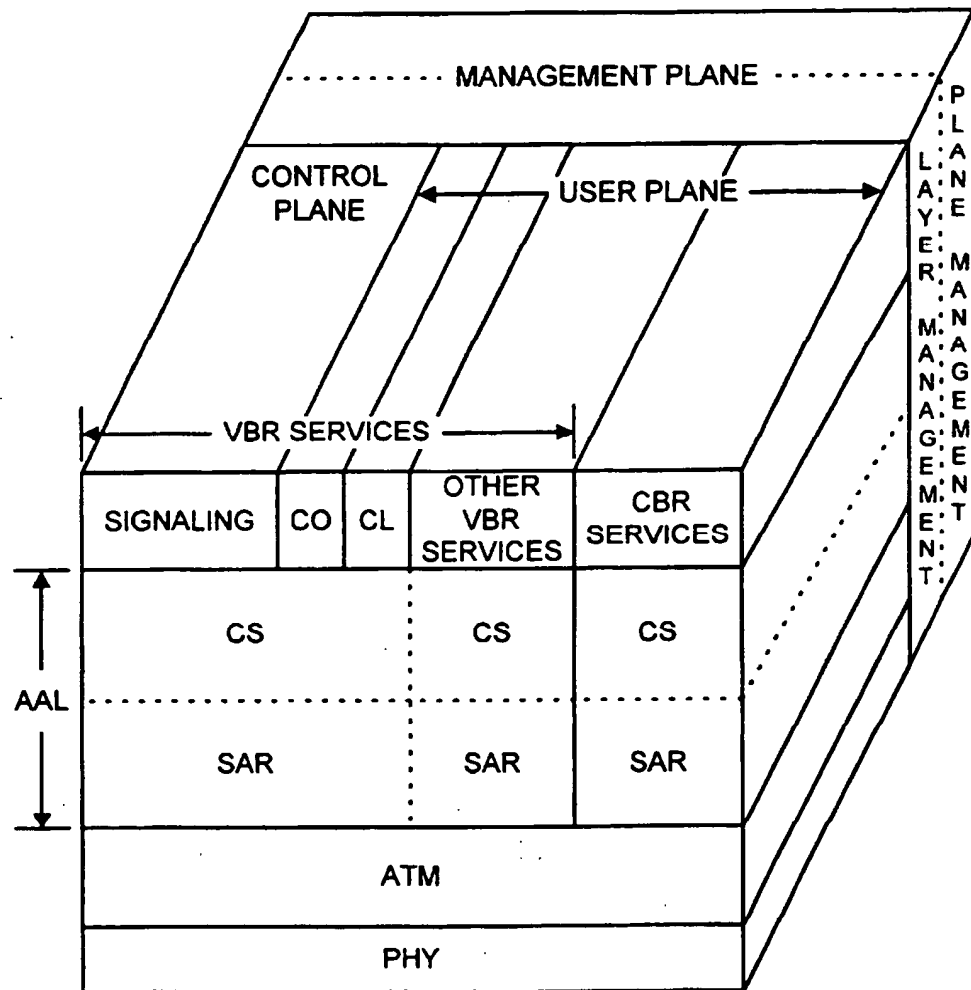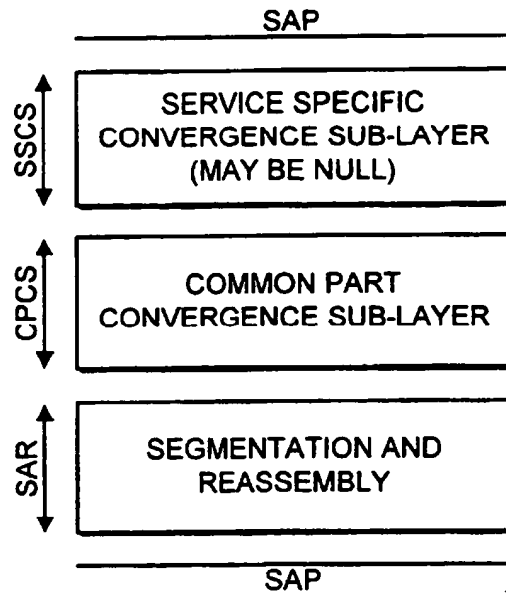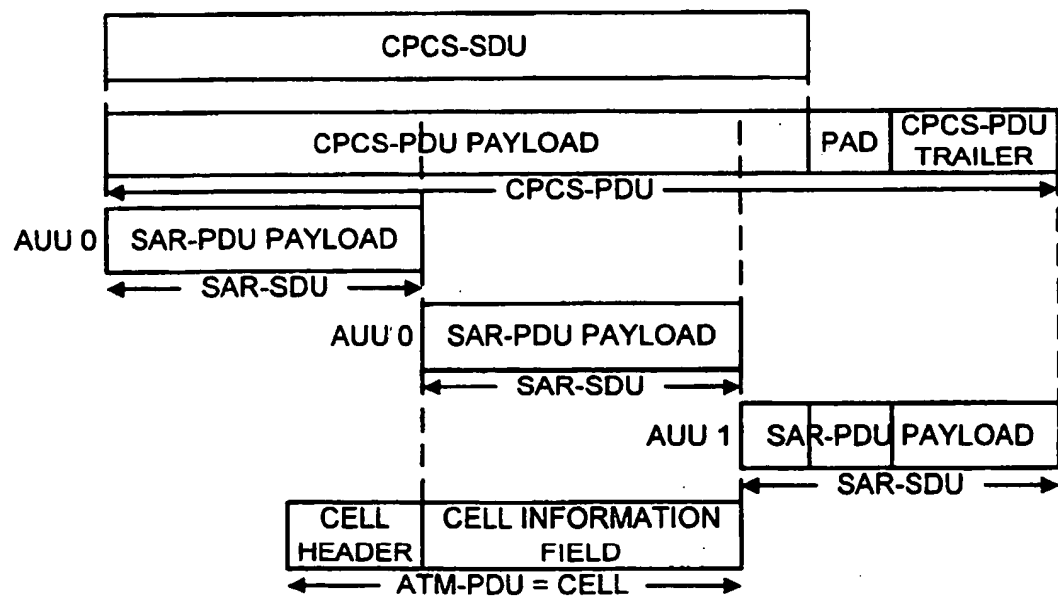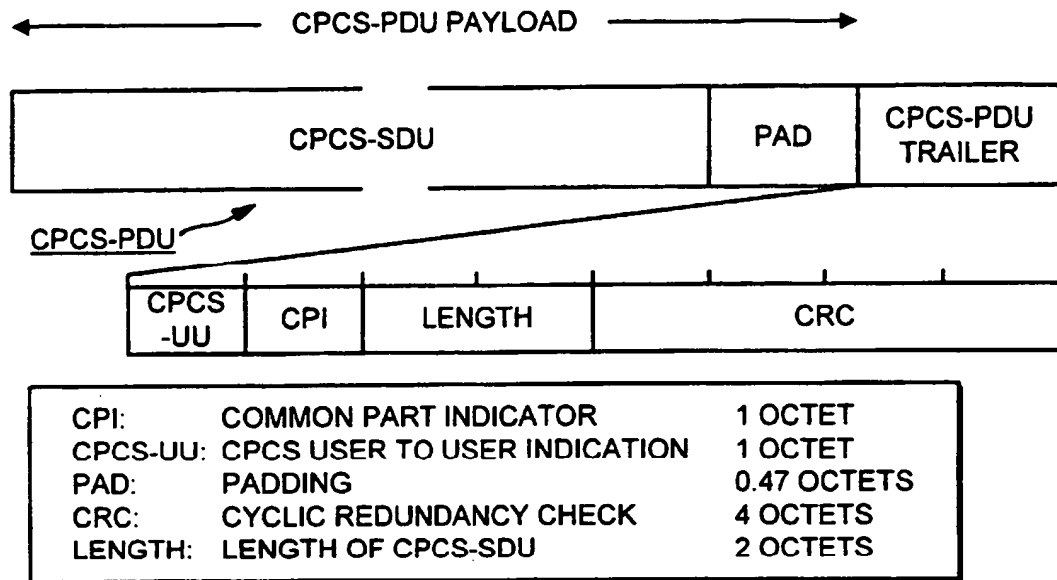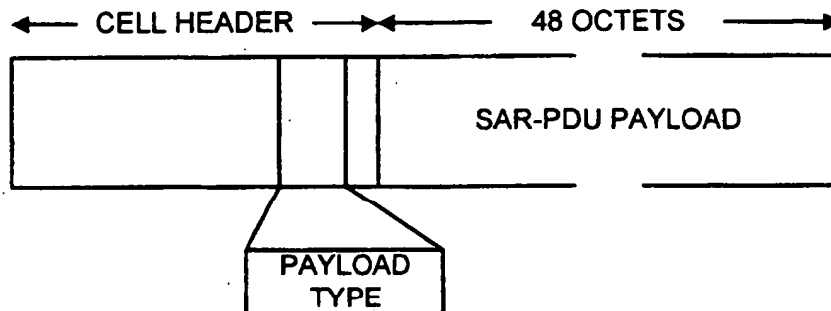
PAYLOAD TYPE

PAYLOAD TYPE CODING	INTERPRETATION
000	USER DATA CELL, AUU = 0, CONGESTION NOT EXPERIENCED
001	USER DATA CELL, AUU = 1, CONGESTION NOT EXPERIENCED
010	USER DATA CELL, AUU = 0, CONGESTION EXPERIENCED
011	USER DATA CELL, AUU = 1, CONGESTION EXPERIENCED
1XX	NON USER DATA CELL

FIG. 8

RQ_{SAR}

PRIORITY 3   PRIORITY 0 RQ_1

ABR/ UBR	NRT- VBR	RT-VBR	CBR

TRAFFIC MANAGEMENT DEVICE 24_1

SQ_3 SQ_2 SQ_1 SQ_0

PRIORITY 3   PRIORITY 0 RQ_N

ABR/ UBR	NRT- VBR	RT-VBR	CBR

TRAFFIC MANAGEMENT DEVICE 24_N

SQ_3 SQ_0 DESTINATION ADDRESS

36

Rx MEMORY

24

INPUT PORTION	32
CELL RECEIVING CIRCUIT	322
CELL ID CIRCUIT	324
CELL OUTPUT CIRCUIT	326

P1

TO INPUT PORT OF SWITCH FABRIC

UNI

x

x + 1

x + 2

x + 3

PHYSICAL- LAYER DEVICE

P2

10

OUTPUT PORTION	34

FROM OUTPUT PORT OF SWITCH FABRIC

26

TO SAR DEVICE

Tx MEMORY

38

PRIORITY 3   PRIORITY 0   DATA PORT

ABR/ UBR	NRT- VBR	RT-VBR	CBR

DATA PORT x

SQ_3 SQ_2 SQ_1 SQ_0 TQ_x

PER VC QUEUING PER O/P PORT

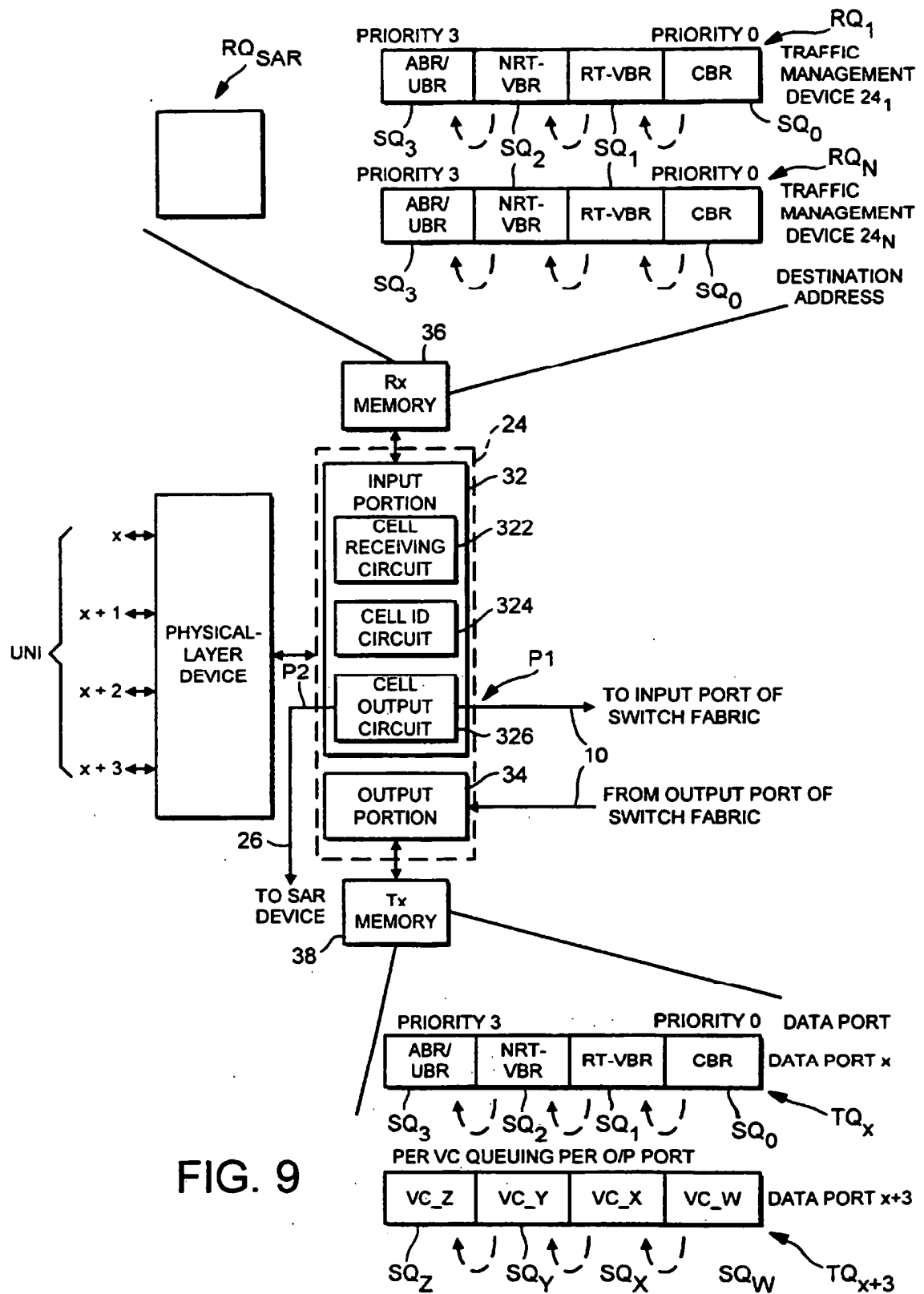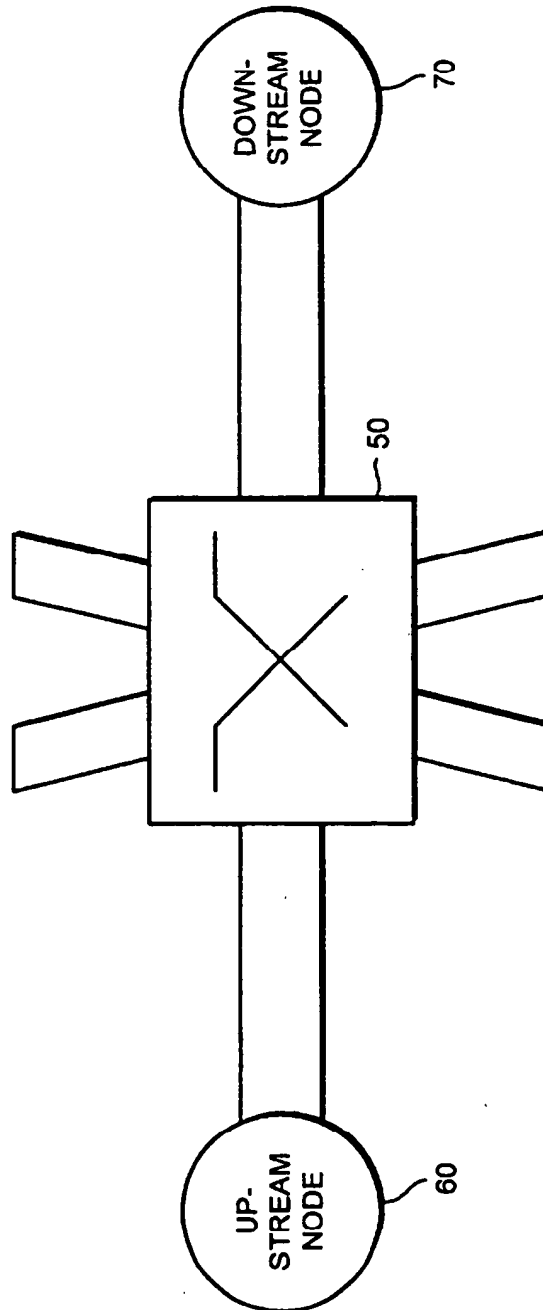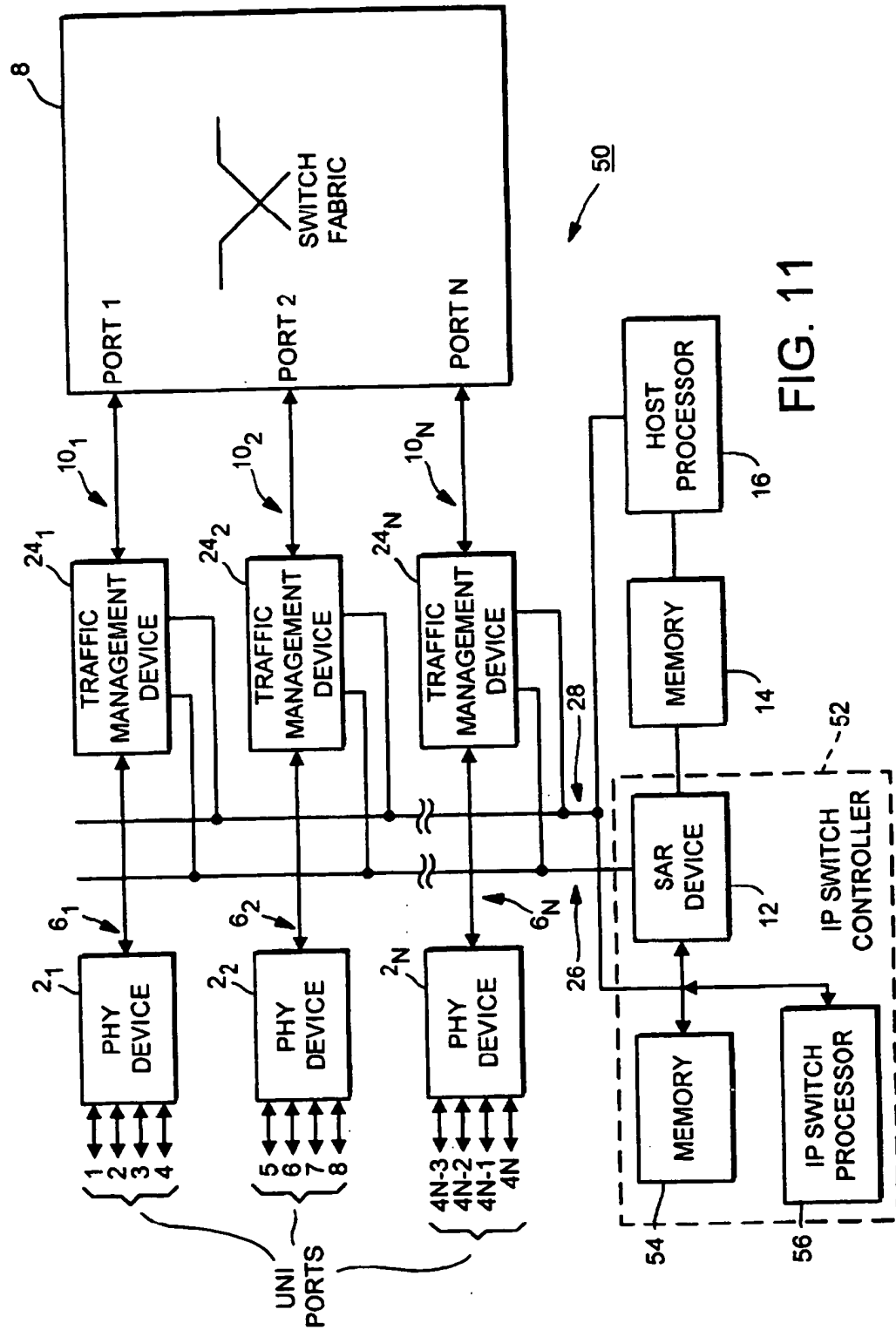| VC_Z	VC_Y	VC_X	VC_W

DATA PORT x+3

SQ_Z SQ_Y SQ_X SQ_W TQ_{x+3}
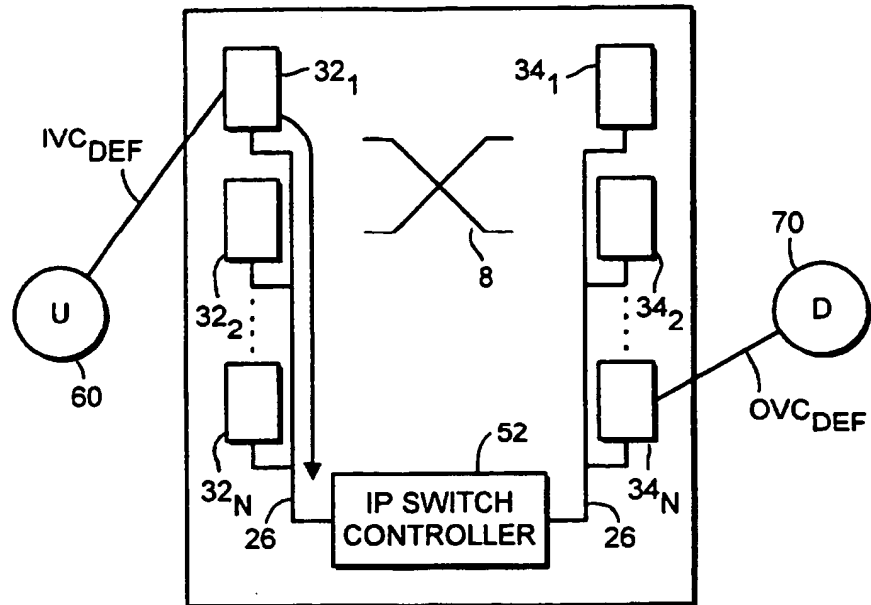
FIG. 9
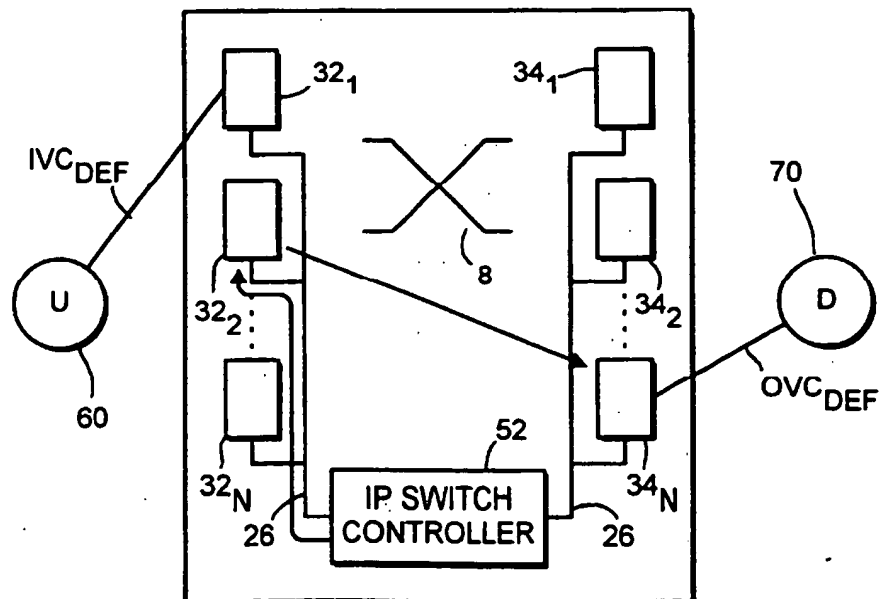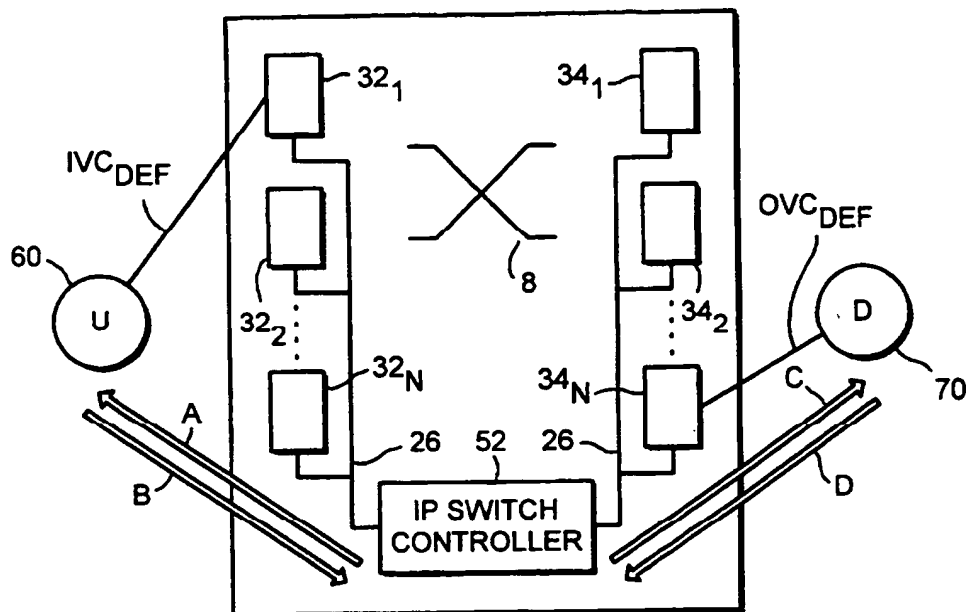
FIG. 10

FIG. 11

FIG. 12(A)
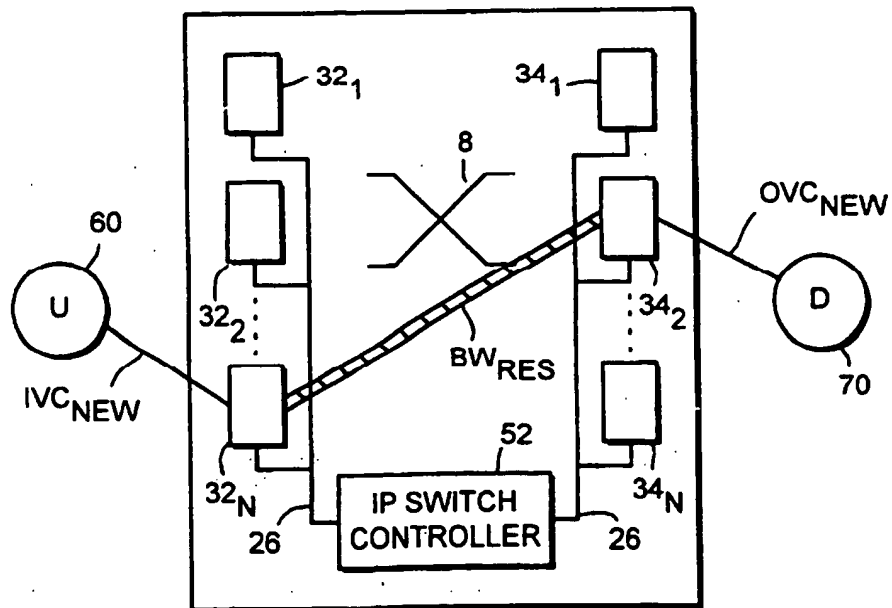

FIG. 12(B)

FIG. 12(C)

FIG. 12(D)

INTERFACING TO SAR DEVICES IN ATM SWITCHING APPARATUS

The present invention relates to interfacing to segmentation-and-reassembly (SAR) devices in asynchronous transfer mode (ATM) switching apparatus.

Figure 1 of the accompanying drawings shows parts of conventional switching apparatus for use in an ATM communications network. The Figure 1 apparatus comprises a plurality N-1 of physical-layer devices 2_1, 2_2,...2_{N-1} and a corresponding plurality N-1 of traffic management devices 4_1, 4_2,...4_{N-1}. Each traffic management device 4_i is connected to its corresponding physical-layer device 2_i by a bi-directional data delivery path 6_i.

The Figure 1 apparatus also includes a switch fabric 8 which is, for example, a N x N cross-connect switching unit. The switch fabric 8 in fact has N input ports and N output ports. Each traffic management device 4_i is connected by a bi-directional data delivery path 10_i to a port-pair, made up of one input port and one output port. Accordingly, for the sake of simplicity, only the port-pairs are shown in Figure 1.

The Figure 1 apparatus also includes a segmentation-and-reassembly (SAR) device 12 which is connected to the port-pair N of the switch fabric 8 by a bi-directional data delivery path 10_N. This SAR device 12 is in turn connected to an associated memory 14. Finally, the apparatus 1 includes a host processor (or switch controller) 16 which is connected to each of the traffic management devices 4_1 to 4_{N-1} and to the memory 12.

In use of the Figure 1 apparatus, the physical-layer devices 2_1 to 2_{N-1} provide the apparatus 1 with a plurality of bi-directional ports (user-network interface or UNI ports) which are connected to physical-layer transmission lines. These physical-

layer transmission lines may be, for example synchronous digital hierarchy (SDH) or synchronous optical network (SONET) transmission lines (ITU-T standard G.709), plesiochronous digital hierarchy (PDH)

5   transmission lines (ITU-T G.703 standard), or fibre-distributed data interface (FDDI) transmission lines (4b/5b standard specified by the ATM Forum). In an ATM network, these transmission lines carry ATM cells in the form of a bit stream the format of which is

10 dependent upon the particular physical medium used to provide the transmission line concerned. In the data-receiving direction (the direction in which cells are admitted into the switching apparatus) the physical-layer devices 2_1 to 2_{N-1} convert the bit streams

15 received at the UNI ports of the apparatus into streams of ATM cells which are delivered to the traffic management devices 4_1 to 4_{N-1} via the respective data-delivery paths 6_1 to 6_{N-1}.

The traffic management devices 4_1 to 4_{N-1} control

20 the delivery of ATM cells to the switch fabric 8. The switch fabric 8 can provide up to N simultaneous data transfer paths, each path serving to permit transfer of data from a selected one of its input ports to a selected one of its output ports. The traffic

25 management devices use these data transfer paths to exchange (switch) ATM cells synchronously. Overall control of the exchange process is normally performed by the host processor 16 which monitors the traffic flow conditions and selects the data transfer paths in

30 successive time slots in order to provide a fair allocation of switch resources amongst the different cell flows passing through the apparatus.

After a traffic management device 4 receives an ATM cell through one of the data transfer paths

35 provided by the switch fabric, it transfers that cell to its corresponding physical-layer device via the data

delivery path 6. Each physical-layer device 2 converts
the stream of ATM cells received thereby into bit
streams suitable for transmission over the ATM
transmission lines connected to the UNI ports of the
5   physical-layer device concerned.

In an ATM network in which the Figure 1 apparatus
is used, most, but not all, of the ATM cell traffic
carried is user data, whether that data represents
voice signals, video signals, files, etc. However,
10   some of the traffic carried by the network inevitably
comprises control information such as signalling
messages. Such signalling messages are required, for
example, to establish a call. In addition, there may
be a requirement for the host processors at different
15   nodes of the ATM network (including the host processor
16 shown in Figure 1) to communicate with one another
using so-called "inter-host communication messages".

The signalling messages and inter-host
communication messages are transferred across the ATM
20   network in the form of ATM cells just like ordinary
data traffic. However, the cells making up such
messages are distinguished in some way from cells
representing data, normally by the virtual path
identifier (VPI) and virtual channel identifier (VCI)
25   information contained in the header of each cell. The
signalling messages and inter-host communication
messages are generally too long to fit in the payload
of a single ATM cell. Accordingly, at the source of
each such message, the message is converted into a
30   plurality of ATM cells which are then introduced
successively into the network. This process is
referred to as segmentation. At the destination of the
message, and possibly also at any intermediate node of
the ATM network at which it is desired to have access
35   to the message concerned, the ATM cells making up the
message are combined, in a process referred to as re-

assembly, to reproduce the original message. In the switching apparatus shown in Figure 1, these segmentation and reassembly processes are carried out by the segmentation-and-reassembly (SAR) device 12

5   which is conventionally provided with its own dedicated port-pair (port N in Figure 1) of the switch fabric 8. Thus, when the host processor 16 is informed that an ATM cell, whose VPI/VCI fields indicate that it belongs to a signalling message or an inter-host communications

10   message, has been received by one of the traffic management devices 4 (the "source" traffic management device), the host processor 16 causes a data transfer path to be established from the input port of the switch fabric 8 to which the source traffic management

15   device is connected (for example, input port 1 in the case of the traffic management device 4_1) to the output port N of the switch fabric 8 so that the cell concerned can be delivered from the source traffic management device to the SAR device 12. The SAR device

20   12 then combines that cell with other cells belonging to the same message, using the memory 14, and, once the reassembly process for that message is complete, the message can be read by the host processor 16.

       If the host processor 16 is the source of a

25   signalling message or inter-host communication message it delivers that message to the memory 14 and the SAR device 12 then segments the message to produce a plurality of ATM cells. These cells are then transferred successively to one of the traffic

30   management devices (the "destination" traffic management device), which is the traffic management device whose corresponding physical-layer device is connected to the transmission line through which the cells must be routed to reach the destination of the

35   message. Under the control of the host processor 16, a data transfer path is provided for each successive cell

of the message from the input port N of the switch
fabric 8 to the output port of the switch fabric to
which the destination traffic management device is
connected. After reaching that destination traffic
5   management device 4 the cells are then passed via the
data delivery path 6 to the corresponding physical-
layer device 2 and are output to the required
transmission line through one of the UNI ports for
onward transmission to the destination of the message.

10   In the Figure 1 apparatus, the SAR device 12 is
provided with its own dedicated port-pair (port N) on
the switch fabric and the signalling messages and
inter-host communication messages accordingly all pass
through the switch fabric 8. Although the number of
15   ATM cells involved in such messages is relatively
small, as compared to the total number of ATM cells
passing through the switch fabric, the need to pass the
ATM cells making up the signalling and inter-host
communication messages through the switch fabric
20   inevitably leads to congestion in the switch fabric and
reduces the number of opportunities to switch ATM cells
representing user data. Furthermore, because one of
the port-pairs of the switch fabric must be dedicated
to the SAR device 12, the number of port-pairs
25   available for connection to the traffic management
devices is reduced by one. This ultimately limits the
number of UNI ports of the switching apparatus as a
whole.

          According to a first aspect of the present
30   invention there is provided switching apparatus, for
use in an ATM network, including: a switch fabric for
switching ATM cells; reassembly means for reassembling
packets from ATM cells; and traffic management means
connected for receiving ATM cells delivered to the
35   apparatus and also connected by first data delivery
path means to the said switch fabric and by second data

delivery path means, separate from the first data delivery path means, to the said reassembly means, and operable to identify those received ATM cells that belong to one or more predetermined types of packet,

5 requiring reassembly by the reassembly means, as respective reassembly cells, and to deliver received cells other than such identified reassembly cells to the switch fabric via the said first data delivery path means for switching by the said switch fabric and to

10 deliver the said reassembly cells to the said reassembly means via the said second data delivery path means for reassembly into packets by the reassembly means.

According to a second aspect of the present

15 invention there is provided a traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having reassembly means for reassembling packets from ATM cells delivered to the

20 apparatus, which device includes: cell receiving means for receiving ATM cells; cell identification means connected to the said cell receiving means and operable to identify as respective reassembly cells those received cells that belong to one or more predetermined

25 types of packet requiring reassembly by the said reassembly means of the apparatus; and cell output means having first port means adapted for connection, when the device is in use, to the said switch fabric, and also having second port means, separate from the

30 said first port means, adapted for connection when the device is in use to the said reassembly means, and operable to deliver received cells other than the identified reassembly cells to the said first port means and to deliver the said reassembly cells to the

35 said second port means.

According to a third aspect of the present

invention there is provided a switching method, for use
in ATM-network switching apparatus that includes a
switch fabric for switching ATM cells, reassembly means
for reassembling packets from ATM cells, and traffic

5   management means for receiving ATM cells delivered to
the apparatus, in which method: those received ATM
cells that belong to one or more predetermined types of
packet, requiring reassembly by the reassembly means,
are identified by the traffic management means as

10   respective reassembly cells; received cells other than
such identified reassembly cells are delivered by the
traffic management means to the switch fabric via first
data delivery path means and are switched by the switch
fabric; and the identified reassembly cells are

15   delivered from the traffic management means to the
reassembly means via second data delivery path means
separate from the first data delivery path means, and
are reassembled into packets by the reassembly means.

In the first to third aspects of the present

20   invention the cells requiring reassembly can be sent
directly to the reassembly means without passing
through the switch fabric. Accordingly, all of the
switch ports of the switch fabric are available for use
by the traffic management means to switch the non-

25   reassembly cells. Switch throughput is therefore
increased and contention problems in the switching
apparatus are alleviated.

Packets requiring reassembly may be, for example,
signalling messages (in particular AAL5 messages) or

30   inter-host communication messages (in particular
Interim Local Management Interface (ILMI)
communications between ATM user-network interface (UNI)
management entities).

Packets requiring reassembly may also include

35   internet-protocol packets. In this case, the apparatus
preferably further includes internet-protocol switch

controller means connected with the said reassembly means for examining such reassembled internet-protocol packets to detect packet flows through the switching apparatus. The traffic management means can then send cells needed by the internet-protocol switch controller means directly thereto without those cells passing through the switch fabric.

Preferably, the traffic management means are operable, in a default routing mode thereof, to receive such internet-protocol packets from an upstream node of the ATM network via a predetermined default input virtual channel and to identify, as such reassembly cells, received ATM cells belonging to the said predetermined default input virtual channel and to deliver those cells via the said second data delivery path means to the said reassembly means so as to permit the said internet-protocol switch controller means to detect packet flows from examination of the reassembled packets. The traffic management means are also switchable, upon detection by the said internet-protocol switch controller means of such a packet flow, to operate in an cut-through switching mode in which the cells of subsequent packets making up the detected packet flow are received by the traffic management means via a new input virtual channel, different from the said predetermined default input virtual channel, and are not identified as such reassembly cells and are delivered directly to the switch fabric via the said first data delivery path means.

In this way, cells belonging to detected flows can be routed through the switching apparatus without being reassembled in the switching apparatus by the internet-protocol switch controller means, so as to implement so-called cut-through switching in which the cells of flows are routed directly in hardware. For example, upon detection by the said internet-protocol switch

controller means of such a packet flow, the traffic
management means may be caused to reserve bandwidth for
switching the cells of the detected packet flow via the
said switch fabric.

5   Preferably, reassembled packets not detected by
the said internet-protocol switch controller means as
belonging to a packet flow are segmented into a
plurality of cells which are transferred back to the
traffic management means for delivery to the said

10   switch fabric, so as to implement store-and-forward
routing of the IP packets that do not belong to flows.
After passage through the said switch fabric, the cells
of the said plurality may then be output to a
downstream node of the ATM network via a predetermined

15   default output virtual channel. On the other hand,
during operation of the traffic management means in the
said cut-through switching mode, the cells of the said
subsequent packets making up the detected packet flow
are preferably output by the traffic management means

20   via a new output virtual channel, different from the
said predetermined default output virtual channel.

         In one embodiment, the said traffic management
means include cell identification means operable to
examine the virtual-path-identifier and/or virtual-

25   channel-identifier fields of the header of each
received ATM cell and to determine, in dependence upon
the results of such examination, whether or not the
cell concerned is to be identified as such a reassembly
cell. This makes it possible to identify the

30   reassembly cells quickly and easily.

         Preferably, the apparatus further includes
segmentation means (the segmentation means and the
reassembly means may form part of the same
segmentation-and-reassembly device), which segmentation

35   means are also connected to the said traffic management
means by the said second data delivery path means, and

are operable to segment a packet generated locally in the apparatus into a plurality of ATM cells and to deliver the cells of the said plurality to the traffic management means via the said second data delivery path

5   means. In this arrangement the cells resulting from segmentation can also be delivered to the traffic management means without passing through the switch fabric.

In this case, the second data delivery path means

10   may include respective unidirectional transmit and receive path means, the receive path means serving to deliver the identified reassembly cells from the traffic management means to the reassembly means, and the transmit path means serving to deliver the cells of

15   the said plurality from the said segmentation means to the traffic management means.

In a preferred embodiment, the said traffic management means include a plurality of individual traffic management devices connected respectively to

20   the said switch fabric by the said first data delivery path means for exchanging ATM cells via data transfer paths provided by the switch fabric, and the said second data delivery path means comprise bus means (for example Universal-Test-and-Operations- PHY-Interface-

25   for-ATM (UTOPIA) level 2 "lookalike" bus means) connecting the individual traffic management devices in common to the reassembly means and, if provided, to the said segmentation means. In this arrangement, each traffic management device controls the delivery of

30   cells to one or more associated input ports of the switch fabric, and each traffic management device can send any reassembly cells directly to the reassembly means using the bus means.

To enable the different traffic management devices

35   to share the bus means, it is preferable that the said reassembly means are operable as a master device of the

said bus means and each traffic management device is operable as a slave device of the said bus means. In this case, for example, the said reassembly means include: polling means for polling the traffic management devices to determine if any of them has identified a received ATM cell as being such a reassembly cell; and data reading means operable, if it is determined by the said polling means that one of the said traffic management devices has identified such a reassembly cell, to cause the traffic management device having that cell to deliver it to the reassembly means via the said bus means.

According to a fourth aspect of the present invention there is provided switching apparatus, for use in an ATM network, including: a switch fabric for switching ATM cells; segmentation means for segmenting a packet generated locally in the apparatus into a plurality of ATM cells; and traffic management means connected by first data delivery path means to the said switch fabric and by second data delivery path means, separate from the said first data delivery path means, to the said segmentation means, and operable to receive from the switch fabric via the said first data delivery path means cells that have been switched by the switch fabric and to receive from the segmentation means via the said second data delivery path means the cells of the said plurality, and to output an ATM cell stream including the switched cells received from the switch fabric and the cells of the said plurality received from the segmentation means.

According to a fifth aspect of the present invention there is provided a traffic management device, for use in ATM switching apparatus having a switch fabric for switching ATM cells delivered to the apparatus and also having segmentation means for segmenting packets generated locally by the apparatus

into a plurality of ATM cells to be output from the apparatus, which device includes: cell input means having first port means adapted for connection, when the device is in use, to the said switch fabric, and also having second port means, separate from the said first port means, adapted for connection when the device is in use to the said segmentation means, and operable to receive at the said first port means cells that have been switched by the switch fabric and to receive at the said second port means the cells of the said plurality; and cell output means for outputting an ATM cell stream including the switched cells received from the switch fabric and also including the cells of the said plurality.

According to a sixth aspect of the present invention there is provided a switching method, for use in ATM-network switching apparatus that includes a switch fabric for switching ATM cells, segmentation means for segmenting a packet generated locally in the apparatus into a plurality of ATM cells, and traffic management means for outputting switched cells, in which method: cells that have been switched by the switch fabric are received by the traffic management means from the switch fabric via first data delivery path means; the plurality of cells produced by the segmentation means are received by the traffic management means via second data delivery path means separate from the said first data delivery path means; and an ATM cell stream, including the switched cells received from the switch fabric and the cells of the said plurality received from the segmentation means, is output by the traffic management means.

In the fourth to sixth aspects of the invention, advantages corresponding to the advantages achieved by the first to third aspects of the invention can be obtained even when the switching apparatus has no

reassembly means. The cells resulting from
segmentation can be transferred directly to the traffic
management means without passing through the switch
fabric, freeing up the switch ports of the switch

5   fabric for non-segmentation cells and alleviating
congestion.

According to a seventh aspect of the present
invention there is provided switching apparatus, for
use in an ATM network, including: a switch fabric for

10   switching ATM cells; internet-protocol switch
controller means for detecting internet-protocol flows
through the switching apparatus; and traffic management
means connected for receiving ATM cells delivered to
the apparatus and also connected by first data delivery

15   path means to the said switch fabric and by second data
delivery path means, separate from the first data
delivery path means, to the said internet-protocol
switch controller means, and operable, in a default
routing mode thereof, to identify, as default-routing

20   cells, those received ATM cells belonging to a
predetermined default input virtual channel and to
deliver those cells via the said second data delivery
path means to the said internet-protocol switch
controller means so as to permit the said internet-

25   protocol switch controller means to detect such flows
from examination of the delivered cells, and being
switchable, upon detection by the said internet-
protocol switch controller means of such a flow, to
operate in a cut-through switching mode in which the

30   subsequently-received cells making up the detected flow
are received by the traffic management means via a new
input virtual channel, different from the said
predetermined default input virtual channel, and are
not identified as such default-routing cells and are

35   delivered directly to the switch fabric via the said
first data delivery path means.

According to an eighth aspect of the present
invention there is provided a traffic management
device, for use in ATM switching apparatus having a
switch fabric for switching ATM cells delivered to the
5   apparatus and also having internet-protocol switch
controller means for detecting internet-protocol flows
through the switching apparatus, which device includes:
cell receiving means for receiving ATM cells; cell
output means having first port means adapted for
10   connection, when the device is in use, to the said
switch fabric, and also having second port means,
separate from the said first port means, adapted for
connection when the device is in use to the said
internet-protocol switch controller means; and cell
15   identification means connected to the said cell
receiving means and operable, in a default routing mode
thereof, to identify, as default-routing cells, those
received ATM cells belonging to a predetermined default
input virtual channel and to deliver those cells to the
20   said second port means for transfer to the said
internet-protocol switch controller means so as to
permit the said internet-protocol switch controller
means to detect such flows from examination of the
delivered cells, and being switchable, upon detection
25   by the said internet-protocol switch controller means
of such a flow, to operate in a cut-through switching
mode in which the subsequently-received cells making up
the detected flow are received by the traffic
management device via a new input virtual channel,
30   different from the said predetermined default input
virtual channel, and are not identified as such
default-routing cells and are delivered to the first
port means for transfer directly to the switch fabric.

In the seventh and eighth aspects of the invention
35   it is not necessary that the internet-protocol switch
controller means have reassembly means for reassembling

the identified default-routing cells received from the
traffic management means.

Reference will now be made, by way of example, to
the accompanying drawings, in which:

5   Figure 1, discussed hereinbefore, shows parts of
switching apparatus previously considered for use in an
ATM network;

Figure 2 shows parts of ATM switching apparatus
according to a first embodiment of the present
10   invention;

Figure 3 shows in schematic form a broadband
integrated services digital network (B-ISDN) in which
the Figure 2 apparatus may be used;

Figure 4 shows a layer model for use in explaining
15   communications protocols used in the Figure 3 network;

Figure 5 shows in more detail than in Figure 4 an
ATM adaptation layer (AAL) shown in the Figure 4 model;

Figure 6 is a schematic diagram for use in
explaining segmentation and reassembly processes in
20   accordance with one type of AAL;

Figure 7 shows in more detail than in Figure 6 one
of the data entities employed in the segmentation and
reassembly processes of Figure 6;

Figure 8 shows the format of a ATM cell employed
25   in the Figure 6 segmentation and reassembly processes;
and

Figure 9 shows a schematic view of a traffic
management device employed in the Figure 2 switching
apparatus, for use in explaining operation of the
30   apparatus;

Figure 10 shows a block diagram showing parts of
an ATM network including switching apparatus according
to a second embodiment of the present invention;

Figure 11 shows parts of ATM switching apparatus
35   according to the second embodiment of the present
invention; and

Figures 12(A) to 12(D) are schematic diagrams for use in explaining operation of the Figure 11 apparatus.

Figure 2 shows parts of ATM switching apparatus embodying the present invention. In Figure 2, parts
5   which correspond to parts already described before with reference to Figure 1 will be denoted by the same reference numerals.

In the Figure 2 switching apparatus 21, each traffic management device 24_1 to 24_N is modified as
10   compared to the traffic management devices 4_1 to 4_{N-1} described hereinbefore with reference to Figure 1. As in the Figure 1 apparatus, each traffic management device 24_i is connected to its corresponding physical-layer device 2_i by way of a data delivery path 6_i (i =
15   1 to N). Each data delivery path 6_i is a Universal Test and Operations PHY interface (UTOPIA) level 2 path providing in each direction a 16 bit data path for data transfer at up to 622 Mbps (clock frequency ≤ 50MHz). Each physical-layer device 2 and each traffic
20   management device 4 therefore has two ports (one for transmitting and the other for receiving), and both ports use the same protocol and interface definition.

Although for simplicity only one physical-layer device 2_i is shown connected to each traffic management
25   device 24_i in Figure 2, the UTOPIA level 2 path 6_i can in fact permit connection of up to n physical-layer devices to each traffic management device, where n ≤ 8 in the case in which the ATM layer operates at 155 Mbps and n ≤ 4 in the case in which the ATM layer operates
30   at 622 Mbps. The UTOPIA level 2 interface includes five addressing lines, thereby providing a virtual space for up to 31 ports on up to 8 physical-layer devices.

A more complete description of the UTOPIA Level 2
35   interface can be found in "UTOPIA", An ATM-PHY Interface Specification, Level 2, Version 1.0", June

1995, published by the ATM Forum.

Each traffic management device 24_i is also connected by a data delivery path 10_i to a port-pair of the switch fabric 8, which port-pair is made up of an input port and an output port. The data delivery path 10_i can be of any suitable type, parallel or serial, but in the present embodiment the interface for the data delivery path 10_i provided at the traffic management device 24_i is a UTOPIA level 2 "lookalike" (UL2LAL) interface. This has basically the same characteristics as the above-mentioned UTOPIA level 2 standard interface promulgated by the ATM Forum but is described as being a "lookalike" interface to that standard interface because the UTOPIA standard interface is intended to connect ATM-layer devices (such as the traffic management devices) to physical-layer devices, and not to provide connections between two ATM-layer devices such as the traffic management device and the switch fabric.

It is also possible for the data delivery path 10_i to contain a parallel/serial converter so that the path is parallel at the end connected to the traffic management device 24_i and serial at the end connected to the switch fabric. This can enable the number of connection pins on the switch fabric 8 to be reduced, as described in the applicant's copending United Kingdom Patent Application No. 9617110.3. Alternatively, or in addition, plural traffic management devices may be connected to the same port-pair on a time-division-multiplexing basis, again so as to reduce the number of connection pins required on the switch fabric 8, as also described in the applicant's copending application number 9617110.3. The contents of that application, and of the applicant's further copending United Kingdom Patent Application No. 9617100.4, are incorporated herein by reference.

Each traffic management device 24_i is also
connected to the host processor 16 by way of a host bus
28. The host bus is, for example, a bidirectional 32-
bit-wide data path with address lines sufficient in
number to address (poll) individually the N different
traffic management devices 24_1 to 24_N.

The switching apparatus 21 shown in Figure 2
differs from the switching apparatus 1 shown in Figure
1 primarily by virtue of the fact that a further bus
26, referred to hereinafter as the SAR bus, is provided
to connect each traffic management device 24_1 to 24_N to
the segmentation-and-reassembly (SAR) device 12.
Accordingly, unlike in the Figure 1 switching
apparatus, the SAR device 12 is not connected to one of
the port-pairs of the switch fabric 8. The SAR bus 26
is preferably a half-width (8-bit data in each
direction) UL2LAL interface. In this case, the SAR
device 12 is the master device, which has control over
the SAR bus 26, and each traffic management device 24_1
to 24_N is a slave device. Alternatively, the SAR bus
26 could be a high-speed serial bus so as to reduce the
pin count of the traffic management devices 24 and SAR
device 12. The second bus may be used to transfer Low
Voltage Differential Signals (LVDS).

The SAR device 12 may be, for example, type
MB86687A manufactured by the applicants.

Operation of the Figure 2 apparatus will now be
described. Before describing the detailed operation of
the apparatus, however, a brief overview will be given
with reference to Figure 3 of a broadband integrated
services digital network (B-ISDN) in which the Figure 2
switching apparatus may be used. It will be understood
that the Figure 2 switching apparatus is not limited to
being used in a B-ISDN, but the B-ISDN serves to
provide a useful example for the purposes of
explanation since it involves connection-oriented

communication protocols that give rise to large numbers of signalling messages (and inter-host communication messages) of the kind which embodiments of the present invention are intended to deal effectively with.

5   However, all communications protocols used in ATM networks, even connectionless protocols, inevitably involve the generation and processing of signalling messages, and embodiments of the present invention are applicable advantageously to all such networks.

10   The B-ISDN network 100 shown in Figure 3 has a plurality of customer premises (CP) nodes 102 corresponding respectively to different customer premises. At each CP node arbitrarily-formatted information supplied by the user is converted into an

15 ATM cell stream, and, in the reverse direction, an ATM cell stream received from the network is converted into user information in the required format. These conversions are performed by an ATM adaptation layer (AAL) in the CP node which serves the function of a

20 terminal adaptor. CP nodes which only generate and receive low-bandwidth ATM cell streams are normally connected by fixed-point transmission facilities to a remote multiplexer node (RMN) 106 at which the individual low-bandwidth ATM cell streams are

25 statistically multiplexed into/demultiplexed from a concentrated link 108. Several such concentrated links 108 are connected to an access node (AN) 110 to which higher-bandwidth CP nodes 102 may also be connected by links 112. A highly-multiplexed ATM cell stream

30 emerging from the access node 110 is carried to a local exchange node (LEN) 114 to which other RMNs 106 and even very-high-bandwidth CP nodes 102 may also be connected. The Figure 2 switching apparatus may, for example be used in the LEN 114. The LEN 114 is

35 connected to a tandem exchange node (TEN) 116 which is a larger ATM switch than the LEN 114. Again, the

Figure 2 switching apparatus may be used in the TEN
116.

The B-ISDN network 100 shown in Figure 3 is a
connection-oriented network which requires connection-
oriented communication protocols. Connection-oriented
protocols require a call setup procedure, even though
the information flows between different CP nodes are in
the form of ATM cells with header fields containing the
routing information. The call setup procedure selects
a path or route to be used by all ATM cells associated
with a connection, and the traffic intensity appearing
on each physical link of the network, for example the
links 108 in Figure 3, is controlled by limiting the
number of connections sharing that link. The paths are
selected so as to spread the total applied loads fairly
among all of the network links and packet switching
nodes (for example the LEN 114 and TEN 116), the
intention being to avoid congestion.

If a new connection is admitted, a "virtual
connection" number (i.e. particular virtual path
identifier (VPI) and virtual channel identifier (VCI)
values) is assigned to that connection, and appears in
the VPI/VCI fields of all ATM cells belonging to that
connection. The virtual connection number implicitly
identifies both the source and destination for each
packet upon call establishment. Each switch along the
selected path is informed, using signalling messages,
of the assigned virtual connection number, and is
provided with routing instructions to be followed
whenever an ATM cell containing that virtual connection
number arrives.

The connection-oriented communication protocols
are implemented by a call processing function. This
function is generally the shared responsibility of
processors attached to the geographically-distributed
CP nodes but for the purposes of explanation it is

possible to regard the call processing function as
being implemented as a single centralised processor.
Each CP node has a permanent virtual channel number
assigned to it for communication with the centralised
5   call processor, and the centralised call processor is
connected to the transport network through an ordinary
CP node and therefore appears to the transport network
like any other user or application. A user at a
particular CP node ("source" CP node) may use the
10   permanent virtual connection from that CP node to the
call processor to request a connection to another
desired CP node ("destination" CP node). The requested
connection may be two-way to enable full duplex
operation. The call processor uses a permanent virtual
15   connection from itself to the destination CP node to
ask the destination CP node if it wishes to accept the
requested connection. If so, the call processor
attempts to find a path which, when loaded with the
requested new virtual connection, will still enable the
20   quality of service currently enjoyed by each other
connection already using that path to be maintained at
above the guaranteed minimum level.

        If the destination CP node refuses to accept the
connection, or if a suitable path cannot be found, the
25   connection is blocked and the source CP node is
informed of this using a signalling message sent via
the permanent virtual connection from the call
processor to the source CP node. If, on the other
hand, the connection can be established, all switching
30   nodes along the selected path are informed by the
processor of the new virtual connection number, and are
provided with appropriate routing instructions. For
this purpose, signalling messages are sent from the
call processor to the affected switching nodes via
35   permanent virtual connections. These signalling
messages are required to be delivered to the host

processor in the switching node, for example the host
processor 16 in the Figure 2 switching apparatus. The
way in which the signalling messages are handled within
the Figure 2 apparatus itself will be considered in

5   more detail later on.

Incidentally, in addition to permanent (pre-
configured) virtual connections, switched (dial-up
connectivity) virtual connections can also be used to
carry signalling messages.

10   Once the call has been established, the source and
destination CP nodes exchange information over the
assigned path (or paths, in the case of a duplex
connection). Each ATM cell passing along the assigned
path(s) contains the assigned virtual connection number

15   in its header, and only the header is processed (in
real time, preferably using VLSI circuitry wherever
possible) by the switching nodes to make the required
routing decision. Accordingly, all cells associated
with a given virtual connection follow the same route

20   through the network and are delivered in the same
sequence in which they were generated.

When either the source or destination CP node
wishes to end the call, a process similar to call
establishment is used to effect call release. Again,

25   permanent virtual connections are used to send
signalling messages between the source and destination
CP nodes and the call processor, and between the call
processor and the affected switching nodes.

In the Figure 3 network, just as user information

30   is transported in the form of ATM cells, the signalling
messages between the source and destination CP nodes
and between the call processor and the switching nodes
are also sent in the form of ATM cells. The conversion
of user information and signalling messages into ATM

35   cells is the function of the ATM adaptation layer
(AAL).

Referring to Figure 4, which shows the protocols
relevant to the operation of one of the CP nodes shown
in Figure 3, the ATM adaptation layer for the CP node
may need to support several types of services. User
5   services include connection-oriented, connectionless
and possibly other types of variable bit rate (VBR)
services, and constant bit rate (CBR) services. VBR
services support non-persistent types of traffic having
various different peak data rates, for example bursty
10   data traffic, image files, large database file
transfer, packet video and packet voice. CBR services,
on the other hand, support persistent types of traffic
that have a constant data rate over a prolonged period,
for example digital video and 64k bit/s digital voice.
15   Control signals (signalling messages) are provided as
yet another VBR service.

The AAL has a user interface at which it receives
user-generated information signals, and a control
interface at which it receives control signals. The
20   AAL serves to convert the information and control
signals into a standard format suitable for ATM prior
to introducing these signals into the ATM network, and
to reconstruct the information signals and control
signals from ATM cells arriving from the network prior
25   to outputting them to the user and control interfaces.

The AAL is in turn divided into two sub-layers as
shown in Figure 4. The conversion sub-layer (CS)
performs an encapsulation/de-encapsulation function for
the user-generated signals and control signals. In
30   fact, as shown in Figure 5, in certain types of AAL,
for example AAL3/4 and AAL5, the CS sub-layer has been
further subdivided into a common part conversion sub-
layer (CPCS) and a service specific conversion sub-
layer (SSCS). A number of SSCS protocols have been
35   defined, or are currently under development, to support
specific AAL user services. AAL5 is generally used for

signalling messages.

As shown in Figure 6, which relates to AAL5, at a source CP node an original user-generated information signal, or a control signal, to be transported through the ATM network and ultimately to be delivered to the destination CP node is delivered (after processing in the SSCS, if provided) to the CPCS in the form of a CPCS service data unit (CPCS-SDU). In the CPCS the signal (CPCS-SDU) is encapsulated in a CPCS protocol data unit (CPCS-PDU) as the payload thereof, as shown in Figure 7. The CPCS-PDU also has a padding field, which can be up to 47 octets in length, and an 8 octet trailer, the format of which is shown in more detail in Figure 7. A CPCS-user-to-user (CPS-UU) indication field is used to transparently transfer CPCS user-to-user information. Currently, a common part indicator (CPI) is only used to indicate 64 bit alignment of the trailer and is set to 0, but possible future functions under consideration include the identification of management messages, for fault monitoring purposes etc., and the identification of operation-and-maintenance (OAM) messages. A length field simply indicates the length of the CPCS-PDU payload. The payload length can range from 1 to 65535 octets and must be octet aligned. The length field is used by the receiver to detect the loss or gain of information. The length field is binary encoded with the number of octets. A cyclic redundancy check (CRC) field is used to detect bit errors in the CPCS-PDU. The scope of the CRC covers the whole of the CPCS-PDU including the padding field, the CPCS-UU, the CPI and the length field.

Although as shown in Figure 6 the CPCS-PDU does not have a header, a header may already have been added by a service specific conversion sub-layer (SSCS) in which case that header will accordingly form a part of

the CPCS-SDU.

The whole of the CPCS-PDU is then passed to the SAR sub-layer (Figure 4) which treats the CPCS-PDU as a single field of variable length. As shown in Figure 6, the SAR function then divides the CPCS-PDU into 48-octet segments, each of which constitutes the payload of one SAR-PDU. The last segment may need padding to form a full 48-octet payload. The SAR-PDU further comprises a 5-byte header, as shown in Figure 8.

In the AAL5 SAR function, the main focus is efficiency, and accordingly all of the 48 octets available in an ATM cell payload are used to carry the user or control information. Accordingly, none of the octets of the SAR-PDU payload is available to indicate the beginning, continuation or end of the message. Instead, the payload type (PT) field of the ATM cell header is used by the SAR function to detect the beginning, continuation and end of messages. The usual PT information is still carried in the PT field but is encoded with an ATM-layer-user-to-ATM-layer-user (AUU) parameter to produce the payload type codings shown in Figure 8.

This completes the segmentation process performed by the AAL5 layer. The reassembly process is essentially the reverse of the segmentation process and serves to reconstitute a message (CPCS-SDU or, if applicable, SSCS-SDU) from a plurality of SAR-SDUs.

The ATM layer in Figure 4 is responsible for attaching/stripping the 5 byte header to/from each SAR-PDU to form the 53-octet ATM cell. The physical layer is responsible for placing the cells onto/receiving cells from the transmission link medium. Except in the case of signalling messages directed specifically to it, the nodes of the ATM network shown in Figure 3, i.e. the remote multiplexer, access, local exchange and tandem exchange nodes, operate only on the ATM cell

headers; the 48-byte cell payloads are neither processed nor even read by the ATM network entities.

In addition to the various layers shown in Figure 4, the protocol layer model for the B-ISDN network of Figure 3 also includes a management plane responsible for management of all user and control layers within the CP node. The management plane is involved, for example, in the call setup procedures. A layer management entity of the management plane serves to interface each of the user and control layers and is responsible for providing instructions to those layers (either for local management purposes or for transmittal to the management plane of distant CP nodes) and for accepting replies from those layers (either locally generated or generated within the management plane of some distant CP node).

Returning now to Figure 2, the switching apparatus 21 is provided at a switching node of the ATM network shown in Figure 3, for example at one of the local exchange nodes (LENS) 114 or at one of the tandem exchange nodes (TENs) 116 thereof. The 4N UNI ports of the apparatus 21 are connected to different respective ATM transmission lines that link the switching node to other switching nodes or to ATM network entities such as the one of the access nodes (AN) 110 or one of the customer premises (CP) nodes 102.

The physical-layer devices 2_1 to 2_N convert the respective bit streams received from the ATM transmission lines connected to the UNI ports into ATM cell streams suitable for delivery to the traffic management devices 24_1 to 24_N which are ATM-layer devices. The functions performed by the physical-layer devices 2 include cell rate decoupling, header error control (HEC) header sequence generation/verification; cell delineation; transmission frame adaptation; transmission frame generation and recovery; and bit

timing. The transmission frame adaptation, generation and recovery functions are required because in the physical layer the information may be transmitted in any suitable frame format, for example ITU-T

5   G.707,G.708 and G.709 synchronous digital hierarchy (SDH) format, STM-1 format (155.52Mbit/s) or ITU-T G.751 plesiochronous digital hierarchy (PDH) E3 format (34.368Mbit/s). Other suitable formats include fibre distributed data interface (FDDI) 4b/5b as specified by

10   the ATM Forum.

The respective ATM cell streams produced by the physical-layer devices 2_1 to 2_N are transferred via the respective data delivery paths 6_1 to 6_N to the corresponding traffic management devices 24_1 to 24_N.

15   Figure 9 is a schematic view of one of the traffic management devices 24. The traffic management device includes an input portion 32 and an output portion 34. The input portion 32 includes a cell receiving circuit 322, a cell identification circuit 324 and a cell

20   output circuit 326. The cell output circuit 326 has a first port P1 connected to the transmit part of the data delivery path 10 linking the input portion 32 to its associated input port of the switch fabric, and a second port P2 connected to the SAR bus 26 linking the

25   input portion 32 to the SAR device 12.

The cells arriving at the input portion 32 from the physical-layer device 2 are received by the cell receiving circuit 322.

Under the control of the cell receiving circuit

30   322 the cells arriving at the traffic management device are generally buffered temporarily in a receive memory 36 which may form part of the traffic management device itself or, more usually and as shown in Figure 9, will be a separate memory device such as a static RAM

35   connected by a bus to the traffic management device. The receive memory 36 may be organised, for example, as

a plurality of receive queues RQ_1 to RQ_N corresponding
respectively to the N different traffic management
devices of the apparatus. A further receive queue
RQ_{SAR} is also provided in the receive memory 36, as
will be explained in more detail below.

Each receive queue RQ may also be subdivided into
a plurality of sub-queues SQ_0 to SQ_3 corresponding
respectively to different traffic priority levels. In
Figure 9 priority level 3 (the lowest level)
corresponds to available bit rate (ABR) and unspecified
bit rate (VBR) traffic, priority level 2 corresponds to
non-real-time variable bit rate (NRT-VBR) traffic,
priority level 1 corresponds to real-time (RT) VBR
traffic, and priority level 0 (the highest level)
corresponds to constant bit rate (CBR) traffic.

In the cell identification circuit 324, the cell
header of each received cell is examined to determine
whether the cell forms part of a signalling message or
an inter-host communication message that originated in
the host processor of another ATM network entity. Such
cells may be distinguished from user-data cells based
on the VPI/VCI fields of the cell header. For example,
the permanent virtual connections reserved for
communication of such signalling and inter-host
communication messages may all have the special VCI
value of 5 (but any suitable VPI value). This enables
the cells belonging to signalling and inter-host
communication messages to be distinguished from other
cells making up normal data messages.

Examples of signalling messages include messages
to set up a call (as described previously) and messages
to set up point-to-multipoint connections. Point-to-
multipoint signalling messages also use the VCI value
of 5 because the individual links are set up separately
one at a time. Other examples of dedicated signalling
messages include Meta-Signalling messages (VPI=

arbitrary (VCI=1) and General Broadcast Signalling
(VPI=arbitrary, VCI=2). Inter-host communication
messages may include user-defined messages which again
are identified by assigning the cells making up the
5   message a special VPI/VCI combination. In addition,
inter-host communication messages may also include
Interim Local Management Interface (ILMI)
communications between adjacent ATM UNI Management
Entities (UMEs), as described in more detail in "ATM
10   User-Network Interface Specification", Version 3.1,
Section 4: Interim Local Management Interface
Specification. The cells belonging to such ILMI
communication messages will also be allocated one or
more specific VPI/VCI values (for example VCI=16 and
15   VCI=any suitable value).

When the cell identification circuit 324
determines that a received cell is a user-data cell the
destination traffic management device for the cell
concerned is identified using a routing table
20   accessible by the input portion, and the cell is stored
in the receive queue RQ (and sub-queue SQ if provided)
which corresponds to the destination traffic management
device (and cell priority level). The fill levels of
the different receive queues can be read periodically
25   by the host processor 16 via the host bus 28 so as to
enable the host processor to detect congestion in the
switching apparatus.

The traffic management devices operate
synchronously in successive time slots. In each time
30   slot, the cell output circuit 326 of each traffic
management device is permitted to transfer one (or
possibly more) ATM cells to another one of the traffic
management devices of the apparatus, the switch fabric
8 providing up to N data transfer paths, each between
35   one of its input ports and one of its output ports.
The cell(s) is (are) output from the first port P1 of

the cell output circuit 326. The selection of which
receive queue the cell(s) to be transferred is (are)
taken from is made by the cell output circuit 326 in
accordance with scheduling information provided to the
5   traffic management device by the host processor 16. In
determining the scheduling, the host processor has
regard to possible congestion, but also selects the
source-destination pairs for the traffic management
devices so as to avoid contention problems in the
10   switch fabric. These matters are discussed in more
detail in the applicant's copending United Kingdom
Patent Application No. 9617110.3.

     After passage through the switch fabric, cells
reaching the output portion 34 of the destination
15   traffic management device are again buffered
temporarily in a transmit memory 38. This transmit
memory may, like the receive memory 36, be organised as
a plurality of transmit queues TQ_x to TQ_{x+3}. The
transmit queues TQ correspond respectively to the
20   different UNI ports x to x+3 that are controlled by the
physical-layer device 2 that is connected to the
traffic management device 24 concerned. Each transmit
queue may be subdivided into a plurality of sub-queues
SQ_0 to SQ_3 which may correspond to the different
25   priority levels (as in the case of the transmit queue
TQ_x) or to the different virtual connections VC_W to VC_Z
using the UNI port concerned (as in the case of the
transmit queue TQ_{x+3}).

     When, on the other hand, the cell identification
30   circuit 322 in the input portion 32 of the traffic
management device 24 determines that a cell received
from its corresponding physical-layer device 2 belongs
to a signalling message or inter-host communication
message, the cell is stored temporarily in the further
35   receive queue RQ_{SAR} corresponding to the SAR device 12.
     The SAR device 12, which is the master device for

the SAR bus 26 linking it to the different traffic
management devices 24_1 to 24_N, continually polls the
traffic management devices to find out whether any of
them has received a cell belonging to a signalling or
5   inter-host communication message. If it is informed by
one of the traffic management devices that such a cell
has been received, it instructs the cell output circuit
326 of the traffic management device concerned to read
the cell from the receive queue RQ_{SAR} and to transmit
10   the cell to it via the second port P2 over the SAR bus
26. The transferred cell is then re-assembled with
other cells belonging to the same message by the SAR
device 12, the payload portion of the cell being
treated as the SAR-SDU and (assuming the message is an
15   AAL5 message) the payload type (PT) information in the
PT field of the cell header being decoded to extract
the ATM-layer-user-to-ATM-layer-user (AUU) parameter
which is needed to detect the beginning, continuation
and end SAR-SDUs of the message (cf. Figures 6 to 8
20   above). The memory device 14 connected to the SAR
device 12 is used to store the individual SAR-SDUs
during reassembly of the message. The different SAR-
SDUs belonging to the same message provide segments of
the CPCS-PDU. This PDU includes the CPCS-PDU trailer
25   added by the AAL function at the source of the message.
The length field in the trailer is used by the SAR
device 12 to detect loss or gain of information.
Similarly, the CRC field is used by the SAR device to
detect bit errors in the CPCS-PDU. From the CPCS-PDU
30   payload, the reassembled message (CPCS-SDU) is then
extracted and made available to the host processor 16.
    Incidentally, the SAR device 12 may also be used
to implement the service specific convergence sub-layer
(SSCS), if provided, in which case the CPCS-SDU is
35   converted by the SSCS into the required final message
(SSCS-SDU) prior to delivery of that SDU to the host

processor.

In the host processor 16 the reassembled message
is examined and appropriate action taken in response
thereto. For example, when a new call is set up,
5   signalling messages are sent by the call processing
function of the ATM network to inform the host
processor of the VPI/VCI field allocated to cells
belonging to that new connection and to identify the
UNI ports of the apparatus which the new connection is
10   to use. This information contained in these signalling
messages is registered by the host processor 16 and is
also used by the host processor to update the switch
routing table (or address translation circuit) of the
traffic management device which will receive cells
15   belonging to that new connection as they enter the
switching apparatus so that that traffic management
device routes the cells to the appropriate destination
traffic management device.

If the host processor 16 wishes to send, rather
20   than receive, a signalling message or inter-host
communication message, it stores the message in the
memory 14 ready for segmentation by the SAR device 12.
The SAR device 12 treats the message as a CPCS-SDU (if
a SSCS is provided in the SAR device 12, then the
25   original message is treated as a SSCS-SDU and first
converted into a CPCS-SDU). A CPCS-PDU is then formed,
having the CPCS-SDU as its payload, a padding field,
and a CPCS-PDU trailer (Figure 7). The CPCS-PDU is
then segmented into SAR-SDUs, and each SAR-SDU is used
30   to provide the payload of an ATM cell. The PT
information in the PT field of the cell header is
encoded as shown in Figure 8 to carry the AUU parameter
(AUU=0 for cells constituting the beginning and
continuation of the message, and AUU=1 for the cell
35   constituting the end of the message). The VPI/VCI
values needed to route the cells to the intended

destination are also loaded into the VPI/VCI fields of each cell. For example, a permanent virtual connection may have been reserved for communication between the host processor 16 and the host processor in the

5   destination CP node or other switching node. In this case, the special VPI/VCI values assigned to that permanent virtual connection (e.g. VCI = 5, VPI value = arbitrary) are loaded into the VPI/VCI fields of each cell.

10   The SAR device also identifies the destination traffic management device for the cells belonging to the message, which device is the traffic management device whose corresponding physical-layer device controls the UNI port from which the cells are to be

15   output from the switching apparatus. The SAR device 12 then transfers the cells via the SAR bus 26 to the destination traffic management device, and the cells are stored in the transmit memory 38 in that one of the transmit queues TQ which corresponds to the UNI port

20   from which the cells are to be output. The cells are then transferred from the transmit queue concerned to the UNI port via the physical-layer device 2 under the control of the output portion 34 of the traffic management device.

25   It will be appreciated that, unlike the Figure 1 switching apparatus in which the SAR device was connected to a port of the switch fabric, in the Figure 2 apparatus the ATM cells making up signalling and inter-host communication messages can be transmitted

30   directly from the traffic management devices to the SAR device. All of the ports of the switch fabric are therefore available for switching cells representing user information, which is the predominant information to be switched. Accordingly, the number of UNI ports

35   which the Figure 2 apparatus is able to support is greater than that possible with the Figure 1 apparatus.

Furthermore, because the cells destined for the SAR device are diverted directly to the SAR device by the traffic management devices, rather than having to pass through the switch fabric, contention in the switch

5 fabric caused by the signalling and other messages is avoided.

It will be appreciated that, although the foregoing embodiment used AAL 5 communication protocols, this is not essential to the invention and

10 any suitable communication protocols requiring segmentation and reassembly functions can be used in embodiments of the present invention.

Furthermore, although in the foregoing embodiment cells which belong to signalling messages and inter-

15 host communication messages were distinguished from other cells on the basis of the VPI/VCI values assigned to the cells, any suitable method of distinguishing the signalling/inter-host communication message cells from user-data cells can be used.

20 Another embodiment of the present invention will now be described with reference to Figures 10 to 12(D). In this embodiment, as shown in Figure 10, the switching apparatus is used to implement an Internet Protocol (IP) switch 50 which is arranged between an

25 upstream node 60 of an ATM network and a downstream node 70. The upstream and downstream nodes communicate using Internet Protocols.

Referring now to Figure 11, which shows the constitution of the switching apparatus 50 in this

30 embodiment, it can be seen that, in addition to the components previously described with reference to Figure 2, the switching apparatus 50 further includes an IP switch controller 52 having its own memory 54 and a IP switch processor 56. Both the memory 54 and the

35 IP switch processor 56 are connected to the host bus 28 which links the host processor 16 of the switching

apparatus to each of the traffic management devices 24_1 to 24_N.

The SAR device 12 is shown in Figure 11 as part of the IP switch controller 52 but this is not essential
5   and the SAR device 12 could be external to the IP switch controller 52 since it is used both by the host processor 16 and by the IP switch processor 56. The SAR device 12 is connected to the internal memory 54 and the IP switch processor 56 of the IP switch
10   controller 52 by an extension of the host bus 28.

In Figure 11, the IP switch controller 56 is shown separately from the host processor 16 but, depending upon the size of the switching apparatus, a single processor could be used to provide the host processor
15   16 and the IP switch processor 56. In this case, the memories 14 and 54 could also be combined as a single memory.

Operation of the Figure 11 switching apparatus will now be described with reference to Figures 12(A)
20   to 12(D).

Incidentally, in Figures 12(A) to 12(D), the respective input and output portions 32 and 34 of each traffic management device 24 (see Figure 9) are shown separately for the purposes of illustration, even
25   though physically, for example, the input portion 32_1 and the output portion 34_1 will both form part of the same traffic management device 24_1.

In Figure 12(A), the initial operating condition of the apparatus is shown, in which the upstream node
30   60 has established a predetermined input virtual channel IVC_{DEF} which is used initially as the default forwarding channel for IP packets between the upstream node 60 and the IP switch 50. As shown in Figure 12(A), it is assumed in this case that the default
35   forwarding channel IVC_{DEF} has, as its source traffic management device, the traffic management device 24_1.

A default output virtual channel OVC_{DEF} is also
initialised for use in transferring IP packets from the
switching apparatus 50 to the downstream node 70. As
shown in Figure 12(A), in this case it is assumed that
5   the default of the virtual channel OVC_{DEF} is controlled
by the destination traffic management device 24_N.

The upstream and downstream nodes 60 and 70 use
internet protocols to communicate. IP packets are sent
from the upstream node 60 via the switching apparatus
10   50 to the downstream node 70. These packets may, for
example, be up to 64k bytes in length, and accordingly
each packet must be segmented into a plurality of
individual ATM cells. Initially, each of the cells has
in its header portion a first VPI/VCI combination
15   corresponding to the default input virtual channel
IVC_{DEF} when being transferred from the upstream node 60
to the switching apparatus 50, and has a second VPI/VCI
combination, different from the first VPI/VCI
combination and corresponding to the default output
20   virtual channel OVC_{DEF}, when being transferred from the
switching apparatus 50 to the downstream node 70. The
necessary conversion from the first VPI/VCI combination
to the second VPI/VCI combination is carried out in the
switching apparatus, for example by the input portion
25   32_1 of the source traffic management device 24_1.

When an IP packet is received, cell-by-cell, by
the input portion 32_1 of the source traffic management
device 24_1 via the default input virtual channel
IVC_{DEF}, the individual cells making up that packet are
30   distinguished by the input portion 32_1 from other cells
because each cell header has the first VPI/VCI
combination corresponding to the default input virtual
channel IVC_{DEF}.

For reasons that will be explained in more detail
35   later, the input portion 32_1 passes the cells of the IP
packet via the SAR bus 26 to the SAR device 12. In the

SAR device 12 the cells belonging to the same IP packet are combined to reassemble the packet using the internal memory 54 of the IP switch controller 52.

5   The IP switch processor 56 runs intelligent routing software which examines the reassembled packets in the memory 54 for the purpose of identifying so-called IP flows. When examined, network traffic can be classified into short-lived traffic or longer "flow"-oriented transmissions. These flows can be identified

10   either by examining each packet to determine its type, for example file transfer (FTP), or by identifying conversational pairs. Conversational pairs are characterised by a series of packets that contain the same source and destination address. Flows are

15   unidirectional in nature and lend themselves to being transmitted via a switched connection, thus avoiding processing overhead and delays associated with the examination of each individual packet as in the usual routing process.

20   The IP switch controller 52 is provided to enable the switching apparatus to detect flows and to deal with packets that are determined to constitute flows differently from packets not identified as constituting such flows. As shown in Figure 12(B), if a packet does

25   not form part of a flow, it is simply segmented into individual cells again, and the cells are transferred to the input portion of a selected one of the traffic management devices (for example, in Figure 12(B), the input portion 32_2 of the traffic management device 24_2)

30   for transfer via the switch fabric to the destination traffic management device which in this case is the traffic management device 24_N. From here the cells are output via the default output virtual channel OVC_{DEF} to the downstream node 70. This corresponds to the

35   conventional (store-and-forward) routing process.

Incidentally, the selection of the traffic

management device to which the cells of the segmented packets are sent by the IP switch controller may be determined in dependence the prevailing traffic conditions, for example to avoid congestion/contention in the switching apparatus. Alternatively, the segmented cells could always be sent back to the original source traffic management device (24_1 in this example).

However, this conventional process is relatively slow as a whole IP packet must be received, stored and then forwarded by the IP switch controller 52.

If the IP switch controller 52 determines that a flow exists, based for example on the packet type identifier carried by each reassembled packet or upon the numbers of reassembled packets having the same source and destination addresses in a given period, it produces a signalling message A which is transferred to the upstream node 60 via the SAR device 12 (which segments the signalling message into ATM cells) and one of the traffic management devices 24. The signalling message A informs the upstream node 60 that a flow has been detected and requests the upstream node to use a new input virtual channel IVC_{NEW} to send the packets belonging to that flow to the switching apparatus 50, instead of using the default input virtual channel IVC_{DEF}. The switching apparatus 50 proposes a VPI/VCI combination for the new virtual channel IVC_{NEW}.

If the upstream node agrees to the request and the proposed VPI/VCI combination, it sends a signalling message B back to the IP switch controller 52 via one of the traffic management devices 24 and the SAR device 12 and, from this point onwards, sends each cell belonging to packets of the detected flow with the specified VPI/VCI combination corresponding to the new input virtual channel (IVC_{NEW}) in its header.

Simultaneously, the IP switch controller sends a

further signalling message C to the downstream node 70
via the SAR device 12 and one of the traffic management
devices 24. Like the signalling message A, the
signalling message C informs the downstream node that a
flow has been detected and requests permission to send
the traffic belonging to that flow to the downstream
node using a new output virtual channel OVC_{NEW}, instead
of using the default output virtual channel OVC_{DEF}.
Again, the IP switch controller 52 proposes a VPI/VCI
combination for the new output virtual channel OVC_{NEW}.
If the downstream node 70 agrees to the request and the
proposed VPI/VCI combination, it sends a signalling
message D back to the IP switch controller 52.

Once the new input and output virtual channels
IVC_{NEW} and OVC_{NEW} have been agreed amongst the upstream
node 60, the downstream node 70 and the IP switch
controller 52, the IP switch controller 52 programs the
traffic management devices in the switching apparatus
50 to route the flow directly in hardware. For
example, if as shown in Figure 12(D) the new input
virtual channel IVC_{NEW} delivers cells to the input
portion 32_N of the traffic management device 24_N (the
new "source" traffic management device), and the new
output virtual channel OVC_{NEW} delivers cells from the
output portion 34_2 of the traffic management device 24_2
(the new "destination" traffic management device) to
the downstream node 70, the IP switch controller 52
programs the new source traffic management device 24_N
with suitable address translation data so that cells
received via the new input virtual channel IVC_{NEW} are
identified and passed by the source traffic management
device 24_N via the switch fabric to the destination
traffic management device 24_2, from where they are
output to the downstream node 70 via the output virtual
channel OVC_{NEW}. Accordingly, cells belonging to the
detected flow are no longer transferred by the source

traffic management device 24_N to the SAR device 12 for reassembly and routing, but are transferred cell-by-cell "automatically" through the switching apparatus. The IP switch controller 52 effectively reserves

5   suitable bandwidth BW_{RES} between the source traffic management device 24_N and the destination traffic management device 24_2 for transferring the cells belonging to the flow through the switching apparatus.

The ability for the detected flows to bypass the

10   IP switch controller enables the switching apparatus to forward packets belonging to such flows at rates limited only by the aggregate throughput of the underlying switch engine. Furthermore, because there is no need to reassemble ATM cells into IP packets in

15   the switching apparatus, throughput remains optimised throughout the network.

Although in the above example, the switch to the input virtual channel results in a change of source traffic management device, it will be appreciated that

20   in other instances the source traffic management device could be the same both for the default and new input virtual channels, for example when there is only one physical path linking the upstream node 60 to a single UNI port of the switching apparatus (in this case only

25   the VCI would need to be changed to select the new virtual channel, the VPI staying the same). The same applies to the destination traffic management device used to service the new output virtual channel. It may or may not be the same traffic management device used

30   to service the default output virtual channel, depending on the arrangement of physical paths between the switching apparatus and the downstream node.

In the embodiment described with reference to Figures 10 to 12(D) the SAR bus 26 is utilised to send

35   packets that are to be routed on the default store-and-forward basis by the IP switch controller 52 from the

source traffic management device to the IP switch controller 52. Accordingly, it is not necessary to connect the IP switch controller to a port of the switch fabric, thereby leaving all ports of the switch

5   fabric free for connection to traffic management devices.

The SAR bus 26 may also be used to convey cells belonging to the signalling messages A to D needed to alert the upstream and downstream nodes to the flows

10   (although the signalling messages could also be delivered to the traffic management devices via the host bus 28, if preferred).

CLAIMS

1.   Switching apparatus, for use in an ATM network, including:

a switch fabric for switching ATM cells;

5   reassembly means for reassembling packets from ATM cells; and

traffic management means connected for receiving ATM cells delivered to the apparatus and also connected by first data delivery path means to the said switch
10   fabric and by second data delivery path means, separate from the first data delivery path means, to the said reassembly means, and operable to identify those received ATM cells that belong to one or more predetermined types of packet, requiring reassembly by
15   the reassembly means, as respective reassembly cells, and to deliver received cells other than such identified reassembly cells to the switch fabric via the said first data delivery path means for switching by the said switch fabric and to deliver the said
20   reassembly cells to the said reassembly means via the said second data delivery path means for reassembly into packets by the reassembly means.

2.   Apparatus as claimed in claim 1, wherein the packets of the said predetermined type, or of one of
25   the said predetermined types as the case may be, constitute signalling messages.

3.   Apparatus as claimed in claim 1 or 2, further including host means for controlling operation of the apparatus, which host means are connected operatively
30   to the said reassembly means for receiving therefrom such packets reassembled by the reassembly means.

4.   Apparatus as claimed in claim 3, wherein the packets of the said predetermined type, or of one of the said predetermined types as the case may be,
35   constitute inter-host communication messages directed to the said host means of the apparatus by the host

means of another ATM-network-entity.

5. Apparatus as claimed in any preceding claim, wherein the packets of the said predetermined type, or of one of the said predetermined types as the case may be, include AAL 5 messages.

6. Apparatus as claimed in any preceding claim, wherein the said traffic management means include cell identification means operable to examine the virtual-path-identifier and/or virtual-channel-identifier fields of the header of each received ATM cell and to determine, in dependence upon the results of such examination, whether or not the cell concerned is to be identified as such a reassembly cell.

7. Apparatus as claimed in any preceding claim, further including segmentation means, also connected to the said traffic management means by the said second data delivery path means, and operable to segment a packet generated locally in the apparatus into a plurality of ATM cells and to deliver the cells of the said plurality to the traffic management means via the said second data delivery path means.

8. Apparatus as claimed in claim 7, wherein the said second data delivery path means include respective unidirectional transmit and receive path means, the receive path means serving to deliver the identified reassembly cells from the traffic management means to the reassembly means, and the transmit path means serving to deliver the cells of the said plurality from the said segmentation means to the traffic management means.

9. Apparatus as claimed in claim 7 or 8, wherein the said segmentation means and the said reassembly means form part of the same segmentation-and-reassembly device.

10. Apparatus as claimed in any preceding claim, wherein the said traffic management means include a

plurality of individual traffic management devices
connected respectively to the said switch fabric by the
said first data delivery path means for exchanging ATM
cells via data transfer paths provided by the switch

5   fabric, and the said second data delivery path means
comprise bus means connecting the individual traffic
management devices in common to the reassembly means
and, if provided, to the said segmentation means.

11.   Apparatus as claimed in claim 10, wherein:

10   the said reassembly means are operable as a master
device of the said bus means and each traffic
management device is operable as a slave device of the
said bus means; and

      the said reassembly means include:

15   polling means for polling the traffic
management devices to determine if any of them has
identified a received ATM cell as being such a
reassembly cell; and

          data reading means operable, if it is

20   determined by the said polling means that one of the
said traffic management devices has identified such a
reassembly cell, to cause the traffic management device
having that cell to deliver it to the reassembly means
via the said bus means.

25   12.   Apparatus as claimed in claim 10 or 11, wherein
the said bus means are Universal-Test-and-Operations-
PHY-Interface-for-ATM (UTOPIA) level 2 "lookalike" bus
means.

      13.   Apparatus as claimed in any preceding claim,

30   further including:

          at least one data port for connection, when the
apparatus is in use, to an ATM-network transmission
line carrying a bit stream; and

          physical-layer means connected between the said

35   traffic management means and the or each data port for
converting the bit stream carried by the or each

transmission line into one or more corresponding ATM
cell streams for delivery to the said traffic
management means.

14.   Switching apparatus, for use in an ATM network,
5   including:
          a switch fabric for switching ATM cells;
          segmentation means for segmenting a packet
generated locally in the apparatus into a plurality of
ATM cells; and
10   traffic management means connected by first data
delivery path means to the said switch fabric and by
second data delivery path means, separate from the said
first data delivery path means, to the said
segmentation means, and operable to receive from the
15   switch fabric via the said first data delivery path
means cells that have been switched by the switch
fabric and to receive from the segmentation means via
the said second data delivery path means the cells of
the said plurality, and to output an ATM cell stream
20   including the switched cells received from the switch
fabric and the cells of the said plurality received
from the segmentation means.

15.   A traffic management device, for use in ATM
switching apparatus having a switch fabric for
25   switching ATM cells delivered to the apparatus and also
having reassembly means for reassembling packets from
ATM cells delivered to the apparatus, which device
includes:
          cell receiving means for receiving ATM cells;
30   cell identification means connected to the said
cell receiving means and operable to identify as
respective reassembly cells those received cells that
belong to one or more predetermined types of packet
requiring reassembly by the said reassembly means of
35   the apparatus; and
          cell output means having first port means adapted

for connection, when the device is in use, to the said
switch fabric, and also having second port means,
separate from the said first port means, adapted for
connection when the device is in use to the said
5   reassembly means, and operable to deliver received
cells other than the identified reassembly cells to the
said first port means and to deliver the said
reassembly cells to the said second port means.

16.   A device as claimed in claim 15, wherein the said
10   cell identification means are operable to examine the
virtual-path-identifier and/or virtual-channel-
identifier fields of the header of each received ATM
cell and to determine, in dependence upon the results
of such examination, whether or not the cell concerned
15   is to be identified as such a reassembly cell.

17.   A traffic management device, for use in ATM
switching apparatus having a switch fabric for
switching ATM cells delivered to the apparatus and also
having segmentation means for segmenting packets
20   generated locally by the apparatus into a plurality of
ATM cells to be output from the apparatus, which device
includes:

cell input means having first port means adapted
for connection, when the device is in use, to the said
25   switch fabric, and also having second port means,
separate from the said first port means, adapted for
connection when the device is in use to the said
segmentation means, and operable to receive at the said
first port means cells that have been switched by the
30   switch fabric and to receive at the said second port
means the cells of the said plurality ; and

cell output means for outputting an ATM cell
stream including the switched cells received from the
switch fabric and also including the cells of the said
35   plurality.

18.   Apparatus as claimed in any preceding claim,

wherein the packets of the said predetermined type, or
of one of the said predetermined types as the case may
be, are internet-protocol packets, and the apparatus
further includes internet-protocol switch controller
5   means connected with the said reassembly means for
examining such reassembled internet-protocol packets to
detect packet flows through the switching apparatus.

19. Apparatus as claimed in claim 18, wherein the
traffic management means are operable, in a default
10   routing mode thereof, to receive such internet-protocol
packets from an upstream node of the ATM network via a
predetermined default input virtual channel and to
identify, as such reassembly cells, received ATM cells
belonging to the said predetermined default input
15   virtual channel and to deliver those cells via the said
second data delivery path means to the said reassembly
means so as to permit the said internet-protocol switch
controller means to detect packet flows from
examination of the reassembled packets, and being
20   switchable, upon detection by the said internet-
protocol switch controller means of such a packet flow,
to operate in an cut-through switching mode in which
the cells of subsequent packets making up the detected
packet flow are received by the traffic management
25   means via a new input virtual channel, different from
the said predetermined default input virtual channel,
and are not identified as such reassembly cells and are
delivered directly to the switch fabric via the said
first data delivery path means.

30   20. Apparatus as claimed in claim 18 or 19, wherein
reassembled packets not detected by the said internet-
protocol switch controller means as belonging to a
packet flow are segmented into a plurality of cells
which are transferred back to the traffic management
35   means for delivery to the said switch fabric.

21. Apparatus as claimed in claim 20, wherein, after

passage through the said switch fabric, the cells of the said plurality are output to a downstream node of the ATM network via a predetermined default output virtual channel.

22. Apparatus as claimed in claim 21, wherein, during operation of the traffic management means in the said cut-through switching mode, the cells of the said subsequent packets making up the detected packet flow are output by the traffic management means via a new output virtual channel, different from the said predetermined default output virtual channel.

23. Apparatus as claimed in any one of claims 19 to 22, wherein, upon detection by the said internet-protocol switch controller means of such a packet flow, the traffic management means are caused to reserve bandwidth for switching the cells of the detected packet flow via the said switch fabric.

24. Switching apparatus, for use in an ATM network, including:

a switch fabric for switching ATM cells;

internet-protocol switch controller means for detecting internet-protocol flows through the switching apparatus; and

traffic management means connected for receiving ATM cells delivered to the apparatus and also connected by first data delivery path means to the said switch fabric and by second data delivery path means, separate from the first data delivery path means, to the said internet-protocol switch controller means, and operable, in a default routing mode thereof, to identify, as default-routing cells, those received ATM cells that make up packets not detected as belonging to such a flow and to deliver those cells via the said second data delivery path means to the said internet-protocol switch controller means;

the traffic management means also being operable

in a cut-through switching mode in which those received
ATM cells that make up packets belonging to such a flow
are delivered directly to the switch fabric via the
said first data delivery path means.

5   25. Apparatus as claimed in claim 24, wherein the
traffic management means serve in the said default-
routing mode to receive the cells making up packets via
a default input virtual channel, and are switchable,
when the internet-protocol switch controller means

10   detect that the packets constitute such a flow, from
the default-routing mode to the said cut-through
switching mode, in which mode the traffic management
means serve to receive the cells making up subsequent
packets of the detected flow via a further input

15   virtual channel, different from the said default input
virtual channel.

26. A traffic management device, for use in ATM
switching apparatus having a switch fabric for
switching ATM cells delivered to the apparatus and also

20   having internet-protocol switch controller means for
detecting internet-protocol flows through the switching
apparatus, which device includes:

        cell receiving means for receiving ATM cells;

        cell output means having first port means adapted

25   for connection, when the device is in use, to the said
switch fabric, and also having second port means,
separate from the said first port means, adapted for
connection when the device is in use to the said
internet-protocol switch controller means; and

30   cell identification means connected to the said
cell receiving means and operable, in a default routing
mode thereof, to identify, as default-routing cells,
those received ATM cells making up packets that have
not been detected as belonging to such a flow and to

35   deliver those cells to the said second port means for
transfer to the said internet-protocol switch

controller means, and also operable in a cut-through switching mode in which those received ATM cells making up packets that have been detected as belonging to such a flow are delivered to the first port means for

5   transfer directly to the switch fabric.

27. A switching method, for use in ATM-network switching apparatus that includes a switch fabric for switching ATM cells, reassembly means for reassembling packets from ATM cells, and traffic management means

10   for receiving ATM cells delivered to the apparatus, in which method:

those received ATM cells that belong to one or more predetermined types of packet, requiring reassembly by the reassembly means, are identified by

15   the traffic management means as respective reassembly cells;

received cells other than such identified reassembly cells are delivered by the traffic management means to the switch fabric via first data

20   delivery path means and are switched by the switch fabric; and

the identified reassembly cells are delivered from the traffic management means to the reassembly means via second data delivery path means separate from the

25   first data delivery path means, and are reassembled into packets by the reassembly means.

28. A switching method, for use in ATM-network switching apparatus that includes a switch fabric for switching ATM cells, segmentation means for segmenting

30   a packet generated locally in the apparatus into a plurality of ATM cells, and traffic management means for outputting switched cells, in which method:

cells that have been switched by the switch fabric are received by the traffic management means from the

35   switch fabric via first data delivery path means;

the plurality of cells produced by the

segmentation means are received by the traffic
management means via second data delivery path means
separate from the said first data delivery path means;
and

5   an ATM cell stream, including the switched cells
received from the switch fabric and the cells of the
said plurality received from the segmentation means, is
output by the traffic management means.

29. A switching method, for use in internet-protocol

10   network switching apparatus that includes a switch
fabric for switching ATM cells, internet-protocol
switch controller means for detecting internet-protocol
flows through the switching apparatus, and traffic
management means for receiving ATM cells delivered to

15   the apparatus, in which method:

those received ATM cells that make up packets
detected as belonging to such a flow are transferred
from the traffic management means to the switch fabric
via first data delivery path means; and

20   those received ATM cells that make up packets not
detected as belonging to such a flow are transferred
from the traffic management means to the internet-
protocol switch controller means via second data
delivery path means separate from the said first data

25   delivery path means.

30. Switching apparatus substantially as hereinbefore
described with reference to Figures 2 to 9, or to
Figures 10 to 12(D), of the accompanying drawings.

31. A traffic management device substantially as

30   hereinbefore described with reference to Figures 2 to
9, or to Figures 10 to 12(D), of the accompanying
drawings.

32. A switching method for use in switching apparatus
substantially as hereinbefore described with reference

35   to Figures 2 to 9, or to Figures 10 to 12(D), of the
accompanying drawings.

The Patent Office

_S2_

Application No:	GB 9708186.3	**Examiner:**	Simon Rees
Claims searched:	1-32	**Date of search:**	29 June 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

    UK Cl (Ed.O): H4K (KTK), H4P (PPS)

    Int Cl (Ed.6): H04Q (11/04), H04L (12/56)

Other: Online: WPI, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP0703718A2	(Brooktree) Whole document.	1-32
A	EP0531599A1	(IBM) Whole document, especially figure 1 and lines 35-51 of column 4.	1-32
A	US5570362A	(Fujitsu) Whole document.	1-32

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
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